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Advanced Materials and Superconductivity

Latest Reports on High-Tc Superconducting Devices

Double-Hole Ti-Based Thin Film RF-SQUID

94P60296A Hefei DIWEN YU CHAODAO
[CRYOGENICS AND SUPERCONDUCTIVITY]
in Chinese Vol 22 No 1, Feb 94 pp 31-34

[Article by Hao Fengzhu [6787 7685 3796] and Chen Jiwen [7115 1323 2429] of MEI Institute 13, Zhang Chaoping [1728 2600 5281] of MEI Institute 16, Yan Shaolin [7051 1421 2651] of the Dept. of Electronics, Nankai University, and Xue Shouqing [5641 1108 3237] of the China National Institute of Metrology: "Double-Hole Ti-Based Thin Film RF-SQUID"; MS received 8 Nov 93]

[Abstract] From a high-Tc TiBaCaCuO superconducting thin film, the authors have fabricated a planar double-hole RF-SQUID [radio-frequency superconducting quantum interference device] which, at a 30-MHz rf bias and without magnetic shielding, exhibits a flux resolution of $0.001\text{--}0.0001 \phi_0/\text{Hz}^{1/2}$ [where ϕ_0 , the magnetic flux quantum, is approximately 2.0679×10^{-7} gauss-m²] in the 100-500-Hz range. Corresponding values of flux resolution (in units of $\phi_0/\text{Hz}^{1/2}$) at other frequencies under 1000 Hz are as follows: 0.01-0.005 in the 0-10-Hz range, better than 0.005 in the 10-100-Hz range, and 0.0001-0.00005 in the 500-1000-Hz range. At liquid-N temperature, the triangular waves in response to the flux supplied measure 10 microvolts peak-to-peak. The device is fabricated by dc magnetron sputtering of the Ti-based superconducting thin film on a ZrO_2 substrate with two 1-mm-diameter flux holes. Film thickness is about 2 microns and T_c is about 110K. Between the two holes is a microbridge 2×3 microns in size. The holes and microbridge were prepared by conventional photolithography with a positive photoresist and wet chemical etching. Parallel double-hole inductance is 4.4×10^{-10} H and critical current is under 10 microamperes.

Figures 1-4, not reproduced, show the following: SEM photographs of the RF-SQUID structure and the microbridge, triangle waves (measured at 73K) of the 20-s-period scan field signal, response under locked-in operating conditions with respect to external field, and typical oscilloscope photos of noise characteristics measured at 78K, respectively. There are no tables.

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1. Hao Fengzhu et al., DIWEN YU CHAODAO [CRYOGENICS AND SUPERCONDUCTIVITY], 18(3), 27 (1990).
2. G. Friedl et al., APPL. PHYS. LETT., 60, 3048 (1992).
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Microwave-Band Ring Resonator

94P60296B Beijing DIWEN WULI XUEBAO
[CHINESE JOURNAL OF LOW-TEMPERATURE
PHYSICS] in Chinese Vol 16 No 2, Mar 94 pp 129-136

[Article by Li Jingwei [2621 7234 4850], Wang Ruilan [3769 3843 5695] et al. of the National Laboratory for Superconductivity, CAS Institute of Physics, Beijing 100080, and Lu Rongrun [4151 2837 3387] of Institute 203, Second Academy, MAS, Beijing 100854: "Design, Q Measurement of High-Tc Superconducting Thin-Film Microwave Ring Resonator," supported by grants from NSFC and the Beijing Zhongguancun Joint Testing Center; MS received 26 Mar 93]

[Abstract] A microwave-band thin-film ring resonator has been developed from a 2100-angstrom-thick high-Tc superconducting $\text{GdBa}_2\text{Cu}_3\text{O}_{7.8}$ thin film fabricated by single-target-deflection dc magnetron sputtering and deposited on a 10 mm x 10 mm x 0.5 mm ZrO_2 single-crystal substrate. The device quality factor Q was measured over the 80-150K temperature range. When input power to the resonator at 81.2K was 0 dBm (i.e. 1 mW), it resonates at 4.212 GHz (frequency for minimum insertion loss, which measures -9.58 dB); the corresponding loaded Q is 176 and the 3dB bandwidth is 24 MHz. Finally, when the Q is extrapolated to zero, the resonator temperature is 89.6K.

Figures 1-8, not reproduced, show the following: ac magnetic susceptibility vs T for the thin film, schematics of the device structure as well as the module and connector, a schematic of the low-temperature thermostat, a schematic of the apparatus for measuring device Q, graphs of device insertion loss vs frequency (in the 3.9-4.3-GHz range) for T = 145K and T = 82.2K, a graph of insertion loss vs frequency for T = 81.2K, a graph of device Q vs T (80-90K range), and a graph of device frequency vs T (same range). There are no tables.

References: 18 English, 2 Chinese.

Infrared Bolometer

94P60296C Beijing DIWEN WULI XUEBAO
[CHINESE JOURNAL OF LOW-TEMPERATURE
PHYSICS] in Chinese Vol 16 No 2, Mar 94 pp 152-156

[Article by Wan Fabao [8001 4099 1405], Xu Ming [1776 2494] et al. of the Dept. of Physics, Northwestern Univ., Xian 710069, and Li Hongcheng [2621 1347 2052], Wang Ruilan [3769 3843 5695] et al. of the National Laboratory for Superconductivity, CAS Institute of Physics, Beijing 100080: "High-Tc Bolometer"; MS received 29 Mar 93]

[Abstract] A theoretical analysis and design are given for a bolometric infrared detector that uses the resistive transition of a high-T_c (91K) superconducting GdBa₂Cu₃O_{7-x} thin film as the temperature-sensing element, and liquid N as the coolant. The device is fabricated by photolithography and rapid ion etching. It is shown that for a highly oriented c-axis Gd-based superconducting thin film, the following best results were obtained: noise equivalent power NEP (500K, 10 Hz, 1 Hz) = 1.4×10^{-11} W/Hz^{1/2}, normalized detectivity D* (500, 10, 1) = 4.2×10^9 cm-Hz^{1/2}/W, and responsivity R_v (500, 10, 1) = 1065 V/W.

Figures 1-2, not reproduced, show a device schematic and thinning R-T curves for the superconducting thin-film detector chip before and after polishing. Tables 1-2, not reproduced, list measured values of NEP, D*, and R_v for various samples, chip structures (resistive, surface impedance, and microbridge), and test dates (ranging from June to November 1992).

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1. "Photoradiation Detectors," trans. by Zhang Zhenjie et al., Shaanxi Province Education Publ. House, Nov 1990.
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Chemical Synthesis, EXAFS Characterization of Nanophase Oxides

94FE0644A Shanghai FUDAN XUEBAO: ZIRAN KEXUE BAN [JOURNAL OF FUDAN UNIVERSITY: NATURAL SCIENCES EDITION] in Chinese Vol 33 No 2, Apr 94 pp 227-231

[Article by Deng Hongmei [6772 4767 2734, principal investigator], Ma Lidun [7456 4409 2415], Shi Guoshun [2457 0948 7311], and Shen Xiaoliang [3088 1321 5328] of the Center for Analysis and Measurement, Fudan University, Shanghai, 200433: "Chemical Synthesis and EXAFS Characterization of Nanoscale Oxides," funded by the Natural Science Youth Foundation of Fudan University; MS received 12 Mar 93]

[Text]

Abstract

Nanoscale Y₂O₃ and nanoscale ZrO₂ granules (their averaged crystal sizes are 25 nm and 14 nm, respectively) are made with a chemical synthesis method. Compacts of the respective oxides are made. Parameters affecting the compacting of nanoscale oxide granules are studied. The characteristics of the extended X-ray absorption fine structure (EXAFS) spectra of different compacts as affected by different pressures and different particle sizes of nanoscale oxides are discussed. The EXAFS spectra of the oxides and the EXAFS spectra of the

nanoscale metallic particles are compared. The results show that in nanoscale oxide compacts the crystal grain boundaries are mainly composed of oxygen atoms.

Key words: Nanoscale material, yttrium oxide, zirconium oxide, EXAFS spectrum.

Up to now, the major method to prepare nanoscale oxides is the gas condensation/in-situ compacting (GCISC) method, as suggested by Gleiter et al.¹ Using this method, Siegel et al.^{2,3} prepared nanoscale TiO₂, nanoscale Al₂O₃, nanoscale ZnO, and nanoscale MgO. However, the GCISC method has its limitations when applied to systems whose components are difficult to evaporate, or easy to decompose. We believe that the chemical synthesis method is promising in overcoming the problem, and through "chemical tailoring," it is promising that new nanoscale ceramic materials of adaptable compositions and properties can be obtained.

The properties of nanoscale materials are greatly affected by their microstructures. Zhu et al.,⁴ using the XRD (X-ray diffraction) analysis method, studied the calculation and measurement of the interference function of nanoscale Fe (n-Fe). The results indicate that the arrangement of atoms along the grain boundaries appears neither in long-range order nor in short-range order. After studying the characteristics of the EXAFS spectra of n-Pd and n-Cu, Haubold et al.⁵ suggested that the grain boundary atoms in nanocrystalline materials are randomly arranged. Recently, using the image simulation technique, Siegel et al.⁶ analyzed n-Pd with a high-resolution transmission electron microscope. The results show that the grain-boundary atom arrangement is similar to that of the traditional coarse polycrystalline material; namely, only portions of the atoms are in orderly arrangement. The EXAFS spectrum study by Eastman et al.⁷ shows that the amplitude decay does not necessarily mean that the grain boundary atom arrangement is random. In China, the grain boundary structures of nanocrystalline metals are being researched by the Hefei Institute of Solid State Physics, Shenyang Institute of Metals Research, Nanjing University, and other organizations. However, current research on nanoscale material structures, here and abroad, focuses mainly on nanocrystalline metals, and there is little research on the grain boundaries of nanoscale oxides.

This paper discusses the preparation of n-Y₂O₃ (25 nm and 35 nm) powder and n-ZrO₂ (14 nm) powder by a chemical method synthesizing nanoscale oxides as well as their powder compacts prepared under different compacting conditions. For the first time, we used the EXAFS analysis to investigate the boundary characteristics of nanoscale oxides and achieved some meaningful results.

1. Experimental Work

(1) Nanoscale Oxides Synthesized by Chemical Method

The urea decomposition and precipitation method is used to prepare n-Y₂O₃. The solutions of Y(NO₃)₃ and urea are mixed according to proper ratio. The mixed solution is aged in an 85°C water bath for 1 hour. Then the solution is quenched and settled with a centrifuge.

The liquid portion is disposed. The precipitate is dispersed in water, supersonically washed five times, and vacuum dried. Then the powder is calcined at 850°C in a tube furnace to form $n\text{-Y}_2\text{O}_3$. A preliminary compact (diameter 13 mm, thickness 2 mm) is pressed in vacuum (about 0.1 Pa). The final $n\text{-Y}_2\text{O}_3$ compact is made by iso-static pressing (about 0.2 GPa).

The $n\text{-ZrO}_2$ powder is synthesized with a sol-gel method. The powder is then surface treated with an organic solvent. The $n\text{-ZrO}_2$ compact is made via the same method used for preparing the $n\text{-Y}_2\text{O}_3$ compact.

(2) Collecting and Treating EXAFS Experimental Data

All samples are ground to particles with averaged crystal size smaller than 5 μm , and then spread on a Scotch film. The film is folded several times to keep the sample thickness uniform. To prevent grain growth, the grinding temperature is maintained at about 0°C.

The experiment is conducted with a synchrotron radiation (KEK [National Laboratory for High Energy Physics, MOE], Tsukuba, Japan) EXAFS experimental device and 4W1B beam line. The energy resolution rate is $\Delta E/E$; and $\Delta E \approx 2$ eV ($E = 17$ kV). Si (311) bicrystal monochromator is used. The data are collected by transmission method. The detector is a gas ionization chamber [I_0 : Ar(50%) + N_2 (50%), I: Ar(100%)]. All the measurements are conducted at 100°K. The CTI cryogenic installation is made by Helix Co., USA.

The data processing is conducted with the FXEA-III program software package [developed] at Fudan University.⁸

2. Results and Discussion

(1) Factors Affecting the Synthesis of Nanoscale Oxides

Quite different from powder prepared with the GCISC method, a portion of the nanoscale oxide powder from chemical synthesis tends to form secondary loose agglomerates. Our experiment shows that after the synthesized nanoscale oxide powder has stayed in vacuum for a period of time (to reduce the air and water molecules to a minimum), the powder can be pressed into an acceptable preliminary compact. Experiments show that the densities of the preliminary $n\text{-Y}_2\text{O}_3$ and $n\text{-ZrO}_2$ compacts reach 59 percent and 50 percent of the corresponding theoretical values, respectively. Iso-static pressing raises their relative densities to 68 percent and 73 percent, respectively. The iso-static pressed $n\text{-ZrO}_2$ compact has higher relative density due to the fact that the $n\text{-ZrO}_2$ powder is made by the sol-gel method which produces more soft agglomerates. While the soft agglomerates make it harder to produce higher density compact by preliminary pressing, the iso-static pressing densifies the compact to a great extent by eliminating the soft agglomerates. The $n\text{-Y}_2\text{O}_3$ powder is composed of uniform loose particles with smaller soft agglomerates, therefore, after iso-static pressing the increase of its compact density is lower than that of $n\text{-ZrO}_2$.

(2) Study of EXAFS

Eastman et al.³ in their study of $n\text{-Pd}$ powder and its EXAFS have found that the amplitude of $n\text{-Pd}$ compact is higher than that of $n\text{-Pd}$ powder but lower than that of $n\text{-Pd}$ foil. In order to broaden the study of the EXAFS spectrum characteristics of nanoscale powder and nanoscale powder compact, we selected the nanoscale oxide systems, and researched the EXAFS characteristics of $n\text{-Y}_2\text{O}_3$ and $n\text{-ZrO}_2$ powders, their preliminary pressed compacts, and their iso-statically pressed compacts. We discover the following features:

- 1) Figures 1 and 2 (no adjustment made on the phase shifts of the coordination distances) show that in $n\text{-oxide}$ systems, the coordination distances r of different coordination planes are basically unchanged under various sample pressing conditions. This finding is consistent with the research results of $n\text{-metal}$ systems.⁷

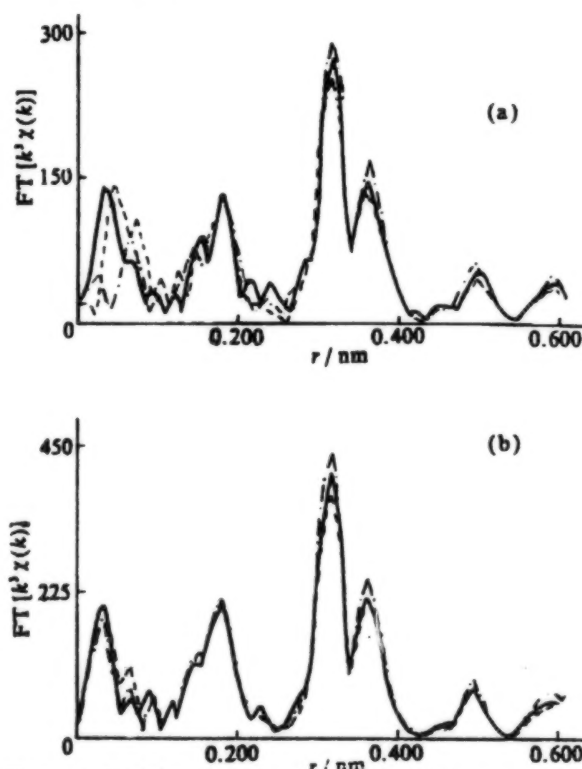


Figure 1. Weight EXAFS spectra of $n\text{-Y}_2\text{O}_3$ powder (---), preliminary compact (solid line), and iso-static pressed compact (dotted line)

(a) Averaged $n\text{-Y}_2\text{O}_3$ grain size, 25 nm; (b) Averaged $n\text{-Y}_2\text{O}_3$ grain size, 35 nm

- 2) The coordination amplitude $\text{FT}[k^3\chi(k)]$ for first M-O ($M = \text{Y or Zr}$) apparent coordination plane remains essentially unchanged. The amplitude of the M-O coordination which corresponds with the M-M coordination (at the neighborhood of 0.4 nm) clearly shows enormous decay. The amplitude decay of the $n\text{-Y}_2\text{O}_3$ system is about 10 percent, and that of the $n\text{-ZrO}_2$ system, above 30 percent.

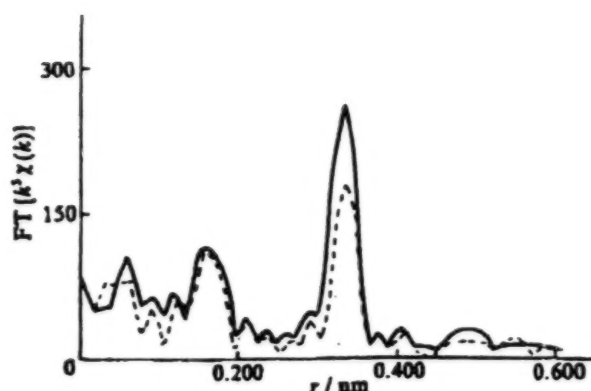


Figure 2. Weight EXAFS spectra of n-ZrO₂ (14 nm) preliminary compact (solid line), and iso-static pressed compact (dotted line)

- 3) Different from the result by Eastman et al.,⁷ the degree of the amplitude decay of n-Y₂O₃ and n-ZrO₂ is enhanced by the increase of sample density. The iso-static pressed compact of the n-Y₂O₃ system has the largest amplitude decay. Due to the fact that the grain size of n-ZrO₂ is smaller than that of n-Y₂O₃, the amplitude decay of the iso-static pressed n-ZrO₂ compact is even more obvious.

From the above, we can see that the characteristics of the n-oxide system are only partially similar to those of the n-metal system. The differences are due to the following:

- 1) The basic properties of the n-oxide system and n-metal system are different. When the powder is pressed, the grain-boundary atomic structure may react differently and cause amplitude decaying differences in the EXAFS spectra of the two systems. The n-Pd structure is of FCC [face-centered cubic] type, and the atomic arrangement in powder is dense. After compacting, the arrangement of boundary atoms becomes even denser. The structures of n-Y₂O₃ and n-ZrO₂ (mixed with Y₂O₃) are of BCC [body-centered cubic] type and cubic type, respectively. Moreover, in powder form, nanoscale oxide is often composed of atomic-cluster bodies which are comparatively loose. Within an atomic-cluster body, the bonds among the atomic clusters are weak. Under iso-static pressure, the rearrangement of atomic clusters in the loose atomic-cluster body may occur, and consequently, may result in a structure with higher relative density and more atoms along the grain boundaries. Therefore, in the n-metal system, the atomic arrangement is dense, and the EXAFS spectrum amplitudes of the compact are slightly higher than those of the powder. However, in the n-oxide system, the increase of the number of atoms in the grain boundary becomes an effective factor, and consequently, the EXAFS spectrum amplitudes of the compact are smaller than those of the powder.

- 2) The different degrees of amplitude weakening between n-oxides and n-metals are also probably caused by the different sample preparation and data collecting methods. In our research, both the prepared n-oxide compact and the powder are ground to particles smaller than 5 μm before conducting the transmission EXAFS spectrum measurement, therefore the data are highly comparable. Eastman et al. adopted different experimental methods for n-Pd powder and compact. They used the transmission method for the powder and the electron probe method for the compact. During data processing, although the EXAFS spectrum signals of different experiment models can be adjusted and corrected to a certain degree, the inevitable occurrence of errors causes difficulty in comparing the results.

- 3) Different from the n-metal system, the n-oxide system has two types of atoms: the oxygen atoms and the metal (Y,Zr) atoms. Our experiment shows that the amplitude near the first M-O coordination peak is not affected by the compacting pressure, but the corresponding amplitude of the M-M coordination peak decreases as the compacting pressure is raised. This phenomenon implies that during compacting, the M-O coordination environment remains unchanged, therefore, the M(Y,Zr) atoms should situate in the center. It can be deduced that grain boundaries in the n-oxides are mainly composed of oxygen atoms. In other words, the increase of compacting pressure possibly makes the numerous oxygen atoms gather along the n-oxide grain boundaries.

In conclusion, in a nanoscale material, the structure of grain-boundary composition and how it affects the EXAFS spectrum signals are closely related to the particular system properties. The atomic arrangement along the grain boundaries of the nanoscale materials varies with different systems. In n-oxide, the grain boundaries are mainly composed of oxygen atoms. A detailed investigation of the n-oxide data analysis and the partial orderly arrangement of grain-boundary atoms is in progress.

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Computers

Intelligent Information Processing Systems Pass State Acceptance Check

94P60300C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 19 May 94 p 1

[Article by Fan Jian [5400 1696]: "Intelligent Information Processing and Intelligent Information Systems Pass State Acceptance Check"]

[Summary] Beijing, 18 May—The "intelligent information processing [techniques] and intelligent information systems" jointly developed by Qinghua University, Beijing University, and Huazhong (Central China) University of Science & Technology (HUST) and funded by NSFC passed State acceptance check today in Beijing. These six techniques and systems, developed over a 4-year period, were appraised by the technical experts as being at least world-class, and in some respects (especially the creativity of the applications) at the world state-of-the-art.

First, the "seismological-prospecting/well-logging intelligent information processing system" developed by CAS Academician and Qinghua University professor Li Yanda [2621 5888 6671] has been successfully used at the Shengli Oil Fields, where it has raised seismological cross-section resolution from 20 m to 12 m. This system employs neural-network pattern recognition techniques. Next, the "learning mechanisms in artificial neural networks" research project undertaken by Qinghua University asst. professor Zhao Nanyuan [6392 0589 0337] has proposed a core theory in cognitive science: the generalized theory of evolution. Prof. Zhao has developed a corresponding engineering cognition theory system incorporating high-level neural activities and opening up new pathways in the study of artificial intelligence. Third, the "computer vision research" project undertaken by CAS Academician and Beijing University professor Shi Qingyun [4258 7230 0061] and oriented

towards development of highly intelligent robots has realized a humanlike monocular system that represents objects in real space by linearly "painted" computer images. Fourth, the "artificial-neural-network-based speaker recognition method" research project of Beijing University professor Chi Huisheng [6688 1920 3932] has resulted in a hybrid-neural-net auditory-model speaker recognition system that for the first time worldwide has discovered certain changes of electrical potential in the brain that occur during the auditory recognition process. Fifth, in a "Chinese-speech recognition/comprehension and Chinese-character/speech compressed output" research project, HUST professor Xu Bingzheng [1776 4426 6927] has developed a Chinese-speech voice-controlled computer printer that has received a State patent and is now in production in Guangdong. Finally, the "information acquisition and sensor technology" project of HUST professor Lin Zhenbiao [2651 2182 7009] has been applied to important problems in radar and search bat sonar systems.

BUAA Achieves Human-Like Intelligent Control of Simple, Double Inverted Pendulums

94P60300D Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 6 Jun 94 p 2

[Article by Chen Xiechuan [7115 0588 1557]: "Beijing University of Aeronautics & Astronautics Successfully Controls Simple Inverted Vertical Pendulum, Double Inverted Vertical Pendulum"]

[Summary] Achievements from the BUAA Automatic Control Department's "humanlike intelligent control theory framework and double inverted pendulum experiment" research project passed China Aerospace Corporation technical appraisal on 27 May. The experiments included successful humanlike control of a simple inverted vertical pendulum and a double inverted vertical pendulum, and are promising breakthroughs for the eventual application of humanlike intelligent control theory to such areas as control of space-launch-vehicle launch towers and bipedal robots and stability in helicopters and other vertical take-off aircraft. According to Qinghua University professor Tu Xuyan [3205 1645 1750], one of the formal appraisal experts, this NSFC-funded research project has reached a world-class level.

Fifty Sino-U.S. GRISYS/ALPHA Systems Used for Domestic Oil Exploration

94P60300B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 18 May 94 p 3

[Article by Xiao Wei [5135 1792]: "50 GRISYS/ALPHA Systems to Be Used for Domestic Large Oil Fields"]

[Summary] The China National Petroleum & Natural Gas Corporation's (CNPC) Globe Software Company, in a collaborative project with the U.S. firm DEC, is porting 50 copies of Globe's domestically made GRISYS seismological processing software package to 50 DEC

ALPHA AXP 64-bit UNIX-OSF/1 workstations, the world's fastest workstations. On 9 May, the two firms jointly unveiled the first GRISYS/ALPHA seismological data processing system and signed a contract for delivery of 50 of these systems to CNPC's major domestic oil fields for use in oil exploration.

CAS Beijing Software Engineering Research Center Develops Sinicized AutoCAD: PICAD

94P60300A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 9 May 94 p 2

[Article by Huai Jin [2037 2516]: "CAS Beijing Software Engineering Research Center Develops Sinicized AutoCAD—PICAD"]

[Summary] The CAS Beijing Software Engineering Research Center has developed a sinicized AutoCAD called PICAD. This copyright-protected domestically designed version of AutoCAD complies with all national standards and provides an excellent Chinese-character interface for users working in an English-language DOS environment.

Expert-System-Based PID Control Technique for Robotic Manipulators

40100072A Hefei MOSHI SHIBIE YU RENGONG ZHINENG [PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE] in Chinese Vol 7 No 1, Mar 94 pp 7-14

[English abstract of article by Sui Qing, Lu Yu, and Ma Songde of the National Laboratory of Pattern Recognition, Institute of Automation, CAS, Beijing 100080; MS received 3 Jul 93]

[Text] In light of robot dynamics being highly nonlinear, substantially coupled, time varying, and uncertain in nature, it is not adequate to only use conventional controls (e.g., PID [proportional integral derivative] control), if accurate performance is desired. In this paper, a PID control technique based on expert system for robotic manipulators (PIDESR) is presented. The PIDESR system combines expert system technology and conventional control techniques and integrates numeric computation with symbolic reasoning, so that process performance can be improved. A two degrees-of-freedom robot is simulated (a Quick C program). The simulation results show that the proposed technique gives more significant performance and robustness than conventional approaches.

Stereo Matching Method Based on Wavelet Transform

40100072B Hefei MOSHI SHIBIE YU RENGONG ZHINENG [PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE] in Chinese Vol 7 No 1, Mar 94 pp 27-33

[English abstract of article by Zhong Sheng, Shi Qingyun, and Cheng Minde of the Center of Information Science, Department of Mathematics, Beijing University, Beijing 100871; MS received 28 Apr 93]

[Text] A binocular correspondence algorithm based on dyadic wavelet transform is presented. Compared with the conventional algorithm, our method achieves higher accuracy and speed (improved by about one order of magnitude). The stereo images are first decomposed on the dyadic wavelet bases. By analyzing the transform coefficients, we get an efficient method to remove noise and extract edges. Some basic constraints for matching, such as the requirement that edges orientate approximately in a same direction, are naturally expressed by the coefficients. More importantly, two useful constraints called "the smooth component gradient constraints" can be deduced for selecting the potential matches. They have strong disambiguation power and greatly remove those potential matches that would cause mismatches, and thus greatly improve the accuracy and speed for matching.

Extraction of Fuzzy Rules by Using f-NN and the Confidence Interval Estimation

40100072C Hefei MOSHI SHIBIE YU RENGONG ZHINENG [PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE] in Chinese Vol 7 No 1, Mar 94 pp 53-59

[English abstract of article by Yang Yupu, Xu Xiaoming, and Zhang Zhongjun of Shanghai Jiaotong University 200030; MS received 13 Oct 93]

[Text] Fuzzy neural network (f-NN) may be used as a new tool for extraction of fuzzy control rules from sensor data. This approach transfers the extraction process into weight estimation of f-NN. Fuzzy rules may be achieved by connectionist learning. The reliability of the extracted fuzzy rules is very important for designing fuzzy control systems. This paper investigates the confidence interval of the fuzzy rules extracted from f-NN by using the method of inferential statistics.

Recognition of Handwritten Numerals by Neural Network

40100072D Hefei MOSHI SHIBIE YU RENGONG ZHINENG [PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE] in Chinese Vol 7 No 1, Mar 94 pp 66-71

[English abstract of article by Hong Qin and He Zheny. of the Radio Eng. Dept., Southeast Univ., Nanjing 210018; MS received 1 Feb 93]

[Text] A new technique for recognition of handwritten numerals is studied. We extract pattern features first and then train a neural network classifier to recognize handwritten numerals. The neural network used in our experiment is a three-layer network with one Gaussian hidden layer, which can be self-configuring during the learning period. Experiments show a good result with our method. The network can be applied to other applications.

Defense Technology

C³I Rapid Prototyping Support System Unveiled

94P60298B Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS] in Chinese
18 May 94 p 1

[Article by Li Weiwei [2621 1792 1792] and Tan Dong [6223 2639]: "C³I Academic Research Enters Internationally Leading Position: Xianfeng-I C³I Rapid Prototyping Support System Developed"]

[Summary] The Xianfeng-I [i.e. "Vanguard-I"] C³I [command, control, communications and intelligence] rapid prototyping support environment developed by the University of Science & Technology for National Defense (USTND) was unveiled in Changsha the other day, indicating that China's C³I rapid prototyping technology has achieved a breakthrough advance propelling the nation into the leading position worldwide in this advanced research field. Long touted by military strategists as "force multipliers," C³I systems are now also finding wide application in the modern information society. Based upon an absorption and analysis of worldwide trends in this leading-edge field, a USTND research group formed in the late 80s and consisting of old professors, young teaching assistants, and graduate students developed this advanced tool for modeling new C³I equipment—a rapid prototyping support system that integrates simulation, prototype automatic generation, distributed execution monitoring, and developmental

management. In addition to defense research, the Xianfeng-I is expected to find applications in R&D of computer integrated manufacturing (CIM) systems, securities trading, computer networks, parallel computers, business management information systems, office automation systems, and robot control systems.

Target Signal Simulator for HF Ground-Wave OTH Radar

94P60298A Harbin HARBIN GONGYE DAXUE
XUEBAO [JOURNAL OF HARBIN INSTITUTE
OF TECHNOLOGY] in Chinese
Vol 26 No 2, Apr 94 pp 56-59

[Article by Yang Yongsheng [2799 3057 4141] and Yu Changjun [0060 7022 6511] of the Dept. of Radio Engineering: "Target Signal Simulator for HF Ground-Wave Radar"; MS received 21 Apr 93]

[Abstract] The target signal simulator, a key piece of test equipment used in the development of high-frequency (HF) ground-wave over-the-horizon (OTH) marine acquisition radars, is described. This computer-controlled radar signal generator simulates precise variable time delay and linear phase shift for both the baseband signal and the carrier signal in order to accurately simulate range and velocity of the returns from a moving target. Gaussian noise is used as the disturbing background.

Figures 1 and 2, reproduced below, show the relationship between the simulator and the radar system and the principle of the HF radar target return simulator. Table 1 below lists system parameters.

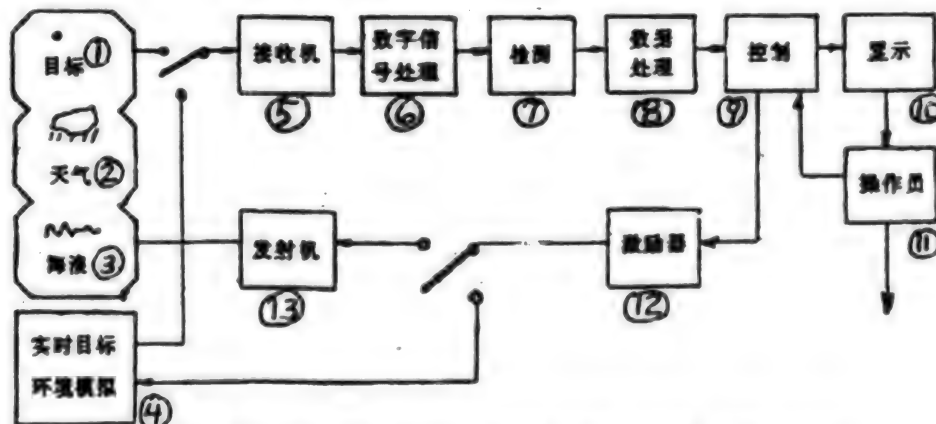


Figure 1. The relationship between the simulator and the radar system.

Key: 1. target; 2. antenna; 3. sea wave; 4. real-time target environment simulation; 5. receiver; 6. digital signal processor; 7. detection; 8. data processing; 9. control; 10. display; 11. operator; 12. exciter; 13. transmitter.

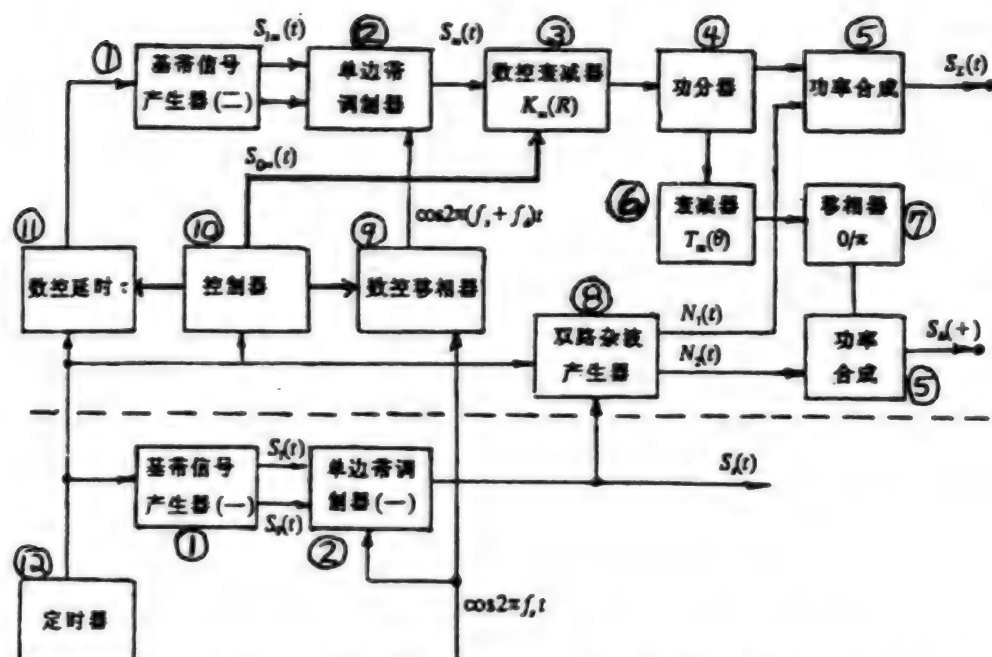


Figure 2. The principle diagram for target return simulator of HF radar.

Key: 1. baseband signal generator; 2. single-sideband modulator; 3. numerically controlled attenuator; 4. power divider; 5. power synthesis; 6. attenuator; 7. phase shifter; 8. two-circuit clutter generator; 9. numerically controlled phase shifter; 10. controller; 11. numerically controlled time delay; 12. timer.

Table 1: System Parameters

		Range	Accuracy
Target param.	Radial speed v	5-100 km/h	≤ 2 percent
	Initial range RO	5n km ($n = 1-30$)	error $\leq \pm 50$ m
	Dynamic range R	$R=vt$, or real-time range $R=RO-vt$	18 m steps
	Bearing	Offset from antenna axis 0-12 degrees	error $\leq \pm 0.5$
Signal param	Carrier freq.	2-5 MHz	—
	Signal amplit.	Initial value set from attenuator, follows range attenuation	1 dB steps
	SNR	Controlled from attenuator, arbitrarily selectable	1 dB steps

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High-Speed Real-Time Processing of 3-mm-Wave Pulse Radar MTD

94P60270A Chengdu DIANZI KEJI DAXUE XUEBAO [JOURNAL OF UNIVERSITY OF ELECTRONIC SCIENCE AND TECHNOLOGY OF CHINA (UESTC)] in Chinese Vol 23 No 2, Apr 94 pp 213-217

[Article by Yu Li [0151 4539], Xia Yuan [1115 0626], and Wang Yiqing [3769 1942 7230] of the Dept. of Electronic Engineering, UESTC, Chengdu 610054: "High-Speed Real-Time Processing of 3-mm-Wave Pulse Radar MTD"; MS received 27 Dec 93, revised 7 Jan 94]

[Abstract] Real-time MTD [moving target detection] processing of 3-mm-wave pulse radar is implemented

with two TMC2310 special-purpose DSP [digital signal processing] chips, one TMS320C30 general-purpose DSP chip, and one TMS320C25 general-purpose DSP chip. The system not only has high processing speed, range resolution, and spectral resolution, it also has easy programmable control. This satisfies requirements for high-performance mm-wave pulse radar signal processing. TMS320-series DSP chips are well known and are not described here. The TMC2310 is a high-speed

FFT [fast Fourier transform] chip first marketed by the U.S. firm TRW in the early 90s.

All three figures are reproduced below. Table 1 lists the following operating performance specifications for the TMC2310: pulse period is 100 microseconds, number of FFT points is 128, FFT operating time is 53.15 microseconds, data storage time is 12.8 ms, and the number of calculable range elements is 240.

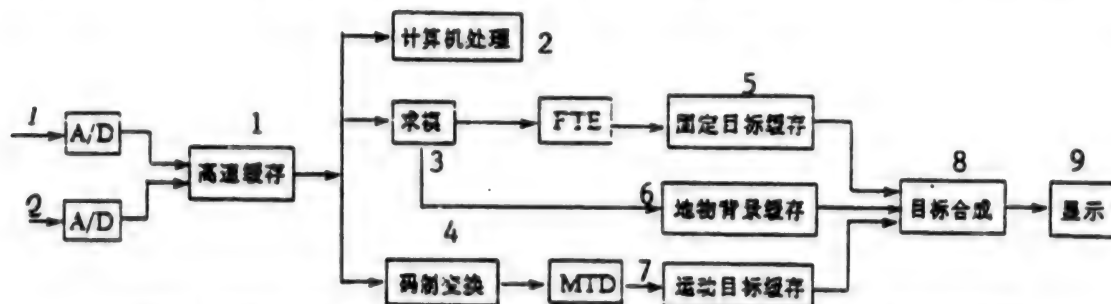


Figure 1. 3-mm-Wave Radar Signal Processing System. FTE=Fixed target enhancement.

Key: 1. cache memory; 2. computer processing; 3. mode determination; 4. code format conversion; 5. fixed target buffer; 6. surface-features background buffer; 7. moving target buffer; 8. target synthesis; 9. display.

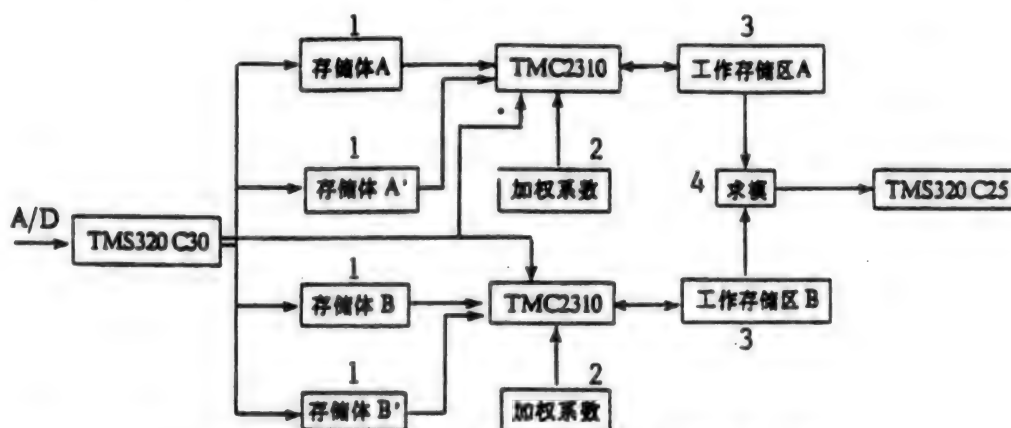


Figure 2. Implementation Scheme for MTD Operating Mode.

Key: 1. memory; 2. weighting factor; 3. operating memory space; 4. mode determination.

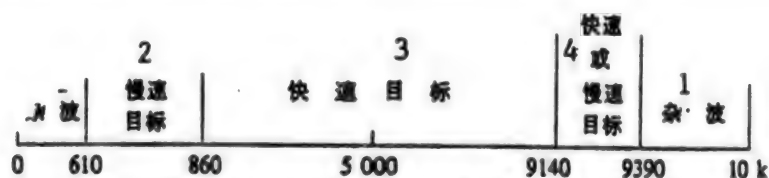


Figure 3. 3-mm Wave Radar Doppler Frequency Division.

Key: 1. clutter; 2. slow targets; 3. fast targets; 4. fast or slow targets.

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5. TMC2310 User's Guide, TRW LSI Products Inc., 1990.

3-D Tracking of Moving Emitters Using Two-Coordinate R-Station

40100073C Changsha GUOFANG KEJI DAXUE XUEBAO [JOURNAL OF NATIONAL UNIVERSITY OF DEFENSE TECHNOLOGY] in English Vol 16 No 1, Mar 94 pp 16-22

[Article by Chen Yongguang and Sun Zhongkang of the Department of Electronic Technology, NUDT, Changsha, 410073; MS received 16 Jun 93]

[Text]

Abstract

The paper presents a 3-D location and tracking algorithm based on the emitter's distance difference between two measurements and azimuth message. The location principle and feasibility of the method are expounded in detail. On condition that an emitter moves linearly at a constant speed, if we can locate and track the emitter only by using azimuth and distance difference without any angle of elevation, the equipment in the receiver will be simplified and the independence of the receiver will be improved as well. Then the algorithm proposed in the paper is of great importance to the practicability of the single observer passive location and tracking system. Performance of this algorithm is evaluated with the help of computer simulation of three typical target paths.

Key words: Tracking, azimuth, filtering

Introduction

Today it becomes more and more dangerous to locate and track moving targets by means of active radars due

to the development of ECM.¹ Therefore radar experts turn their attention to passive location and tracking technique. One of the important uses of SOPLAT is to locate and track moving emitters with passive method. Generally a target's position is determined by measuring its angle of azimuth and elevation relative to the receiver and the difference of time of arrival between two radio waves that are transmitted by the emitter. However some receivers have not any equipment to measure target's angle of elevation, so it is necessary to do research on the ability of single station to locate and track a moving emitter without any elevation message. This paper will discuss a tracking method only using distance difference and azimuth measurements based on the WMEKF algorithm.

1. Location and Tracking Principle

1.1 Special Conditions

- a. The target will fly at a constant speed. In other words v_x , v_y and v_z will not change.
- b. All measuring noises obey Gaussian distribution and are independent of each other.
- c. The repetition interval of emitter signal is known.

1.2 Location and Tracking Principle

For an emitter in the air, let $(\Delta TOA)^m$ represent the difference of time of arrival (mark m represents measurement). If the emitter moves at a constant speed and the noises are considered, then:

$$(\Delta TOA)_{k,k-1}^m = T + (r_{r,k} - r_{r,k-1})/c + \eta_{\Delta k,k-1} \quad (1)$$

$$\beta_k^m = \text{tg}^{-1} \frac{y_k - y_r}{x_k - x_r} + \eta_{\beta,k}$$

where: $\eta_{\Delta k,k-1}$, $\eta_{\beta,k}$ are measuring noises of time difference and azimuth. T is sampling period and c is the speed of light. r_r is the distance between receiver and target. The target's coordinate at point k is (x_k, y_k, z_k) . R-station's coordinate is (x_r, y_r, z_r) .

In the same way distance difference of target to receiver

$$\Delta r_{i,i-j} = c[(\Delta TOA)_{i,i-j}^m - jT]$$

$$= (r_{r,i} - r_{r,i-j}) + \sum_{m=0}^{j-1} \eta_{\Delta r,i-m,i-m-1}$$

between point i and $i-j$ ($i > j$) can be easily written as:

$\eta_{\Delta r} = c\eta_{\Delta}$ is the noise of distance difference that is caused by measuring time difference.

In (1) $(\Delta TOA)^m_{k,k-1}$ contains height message of the target, because:

$$r_{r,k} - r_{r,k-1} = \sqrt{(x_k - x_r)^2 + (y_k - y_r)^2 + (z_k - z_r)^2} - \sqrt{(x_k - Tv_x - x_r)^2 + (y_k - Tv_y - y_r)^2 + (z_k - Tv_z - z_r)^2}$$

On the one hand the height message contained in $(\Delta TOA)^m$ may be extracted in order to locate and track a moving emitter without any elevation message; on the other hand we must notice that there is no height message in β^m , so time difference should be changeful. In other words if the

distance has little change in an emitter path, location will certainly fail. According to what we have discussed it can be said that it is possible to track a 3-D moving emitter by only using time difference and azimuth measurement. Computer simulation will prove this.

2. Filtering Algorithm

2.1 State Function

When an emitter moves at a constant speed and the velocity disturbance is $[w_{x,k}, w_{y,k}, w_{z,k}]$, then:

$$X_{k+1} = \Phi X_k + W_k, \text{ where } X_k = [x_k, y_k, z_k, v_{x,k}, v_{y,k}, v_{z,k}]^T$$

$$W_k = [T^2 w_{x,k}/2, T^2 w_{y,k}/2, T^2 w_{z,k}/2, T w_{x,k}, T w_{y,k}, T w_{z,k}]^T$$

$$\Phi = \begin{bmatrix} 1 & 0 & 0 & T & 0 & 0 \\ 0 & 1 & 0 & 0 & T & 0 \\ 0 & 0 & 1 & 0 & 0 & T \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}, E[W_k] = 0, \text{ COV}(W_k, W_j) = Q_k \delta_{kj},$$

$$Q_k = E[W_k W_k^T] = \begin{bmatrix} T^4 q_x^2/4 & 0 & 0 & T^3 q_x^2/2 & 0 & 0 \\ 0 & T^4 q_y^2/4 & 0 & 0 & T^3 q_y^2/2 & 0 \\ 0 & 0 & T^4 q_z^2/4 & 0 & 0 & T^3 q_z^2/2 \\ T^3 q_x^2/2 & 0 & 0 & T^2 q_x^2 & 0 & 0 \\ 0 & T^3 q_y^2/2 & 0 & 0 & T^2 q_y^2 & 0 \\ 0 & 0 & T^3 q_z^2/2 & 0 & 0 & T^2 q_z^2 \end{bmatrix}$$

2.2 Measurement Functions

In order to increase the stability, observability and accuracy of the filter we intend to use multiple measurement functions to locate the target. Here we will take four measurement functions for example to study the algorithm. But in fact eight ones are used in simulation in order to get better results.

Number K filtering process will use measuring data at point K, $K - N_k$, $K - N_k - I_k$, $K - N_k - I_k - J_k$, N_k , I_k , J_k are not less than 1. Measurement function:

$$Z_k^T = (X_k) + V_k, \text{ where } Z_k^T = [\beta_k^T, \beta_{k-N_k}^T, \beta_{k-N_k-I_k}^T, \beta_{k-N_k-I_k-J_k}^T, \Delta r_{k,k-N_k}, \Delta r_{k-N_k,k-N_k-I_k}, \Delta r_{k-N_k-I_k,k-N_k-I_k-J_k}]^T$$

$$\text{In } Z_k^T \text{ formula, } N_1 = N_k, N_2 = N_k + I_k, N_3 = N_k + I_k + J_k,$$

$$E[V_k] = 0, \text{ COV}(V_k, V_j) = R_k \delta_{kj},$$

$$R_k = \text{diag}[\sigma_\beta^2, \sigma_\beta^2, \sigma_\beta^2, \sigma_\beta^2, N_k \sigma_{\Delta r}^2, I_k \sigma_{\Delta r}^2, J_k \sigma_{\Delta r}^2]$$

2.3 Filtering Algorithm of Azimuth Measurements

According to reference 2 azimuth measurement function meets with condition of WMEKF algorithm. Let us first obtain

$$g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1}).$$

$$\beta_{i-N}^* = \beta_{i-N}^* + \eta_{p,i-N},$$

$$\beta_{i-N}^* = \operatorname{tg}^{-1} \frac{y_i - NT v_{y,i} - y_r}{x_i - NT v_{x,i} - x_r} = h_p^N(X_i) \quad (2)$$

To make formula (2) pseudo linearized, it can be written as: $H_i(Z_i^*)X'_k = 0$, where: $H_i(Z_i^*)$ is:

$$[\sin \beta_{i-N}^*, -\cos \beta_{i-N}^*, 0, -NT \sin \beta_{i-N}^*, NT \cos \beta_{i-N}^*, 0]$$

$$X'_k = [x_k - x_r, y_k - y_r, z_k - z_r, v_{x,k}, v_{y,k}, v_{z,k}]^T$$

If $\beta_{i-N}^* = \beta_{i-N}^* - \eta_{p,i-N}$ is put in and suppose $\cos \eta_{p,i-N} \approx 1$, then: $H_i(Z_i^*)X'_k = T_i(Z_i^*, X_k, V_k)$, where $H_i(Z_i^*)$ is $H_i(Z_i^*)$ when $*$ is replaced by m . According to reference 2,

$$g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1}) = - \frac{Z_i^* - h_i(\hat{X}_{i/k-1})}{H_i(Z_i^*) \hat{X}_{i/k-1}} H_i(Z_i^*), \text{ let,}$$

$$Z_i^* = \beta_{i-N}^*, h_i(\hat{X}_{i/k-1}) = \operatorname{tg}^{-1} \frac{\hat{y}_{i/k-1} - y_r - NT \hat{v}_{y,i/k-1}}{\hat{x}_{i/k-1} - x_r - NT \hat{v}_{x,i/k-1}}$$

$$\hat{X}_{i/k-1} = [\hat{x}_{i/k-1} - x_r, \hat{y}_{i/k-1} - y_r, \hat{z}_{i/k-1} - z_r, \hat{v}_{x,i/k-1}, \hat{v}_{y,i/k-1}, \hat{v}_{z,i/k-1}]^T$$

We obtain $g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1})$.

Four $g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1})$ ($N=0, N_1, N_1+I_1, N_1+I_1+J_1$) form a 4×6 matrix

$$g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1}).$$

And: $\mu_i = \frac{T_i(Z_i^*, X_i, V_i)}{H_i(Z_i^*) \hat{X}_{i/k-1}}$, where $i=1, 2, 3, 4$ are corresponding to $N=0, N_1, N_1+I_1,$

$N_1+I_1+J_1$.

then: $U_i = \operatorname{diag} \left[\frac{1}{1-\mu_{i1}}, \dots, \frac{1}{1-\mu_{i6}} \right],$

$$g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1}) = U_i g_{p,i}^N(Z_i^*, \hat{X}_{i/k-1}),$$

$$R_{p,i} = U_i R_{p,i} U_i^T = \operatorname{diag} \left[\frac{\sigma_i^2}{(1-\mu_{i1})^2}, \dots, \frac{\sigma_i^2}{(1-\mu_{i6})^2} \right]$$

2.4 Filtering Algorithm of Distance Difference Data

The measuring functions of distance difference do not meet with condition of WMEKF algorithm, so we shall have to use EKF algorithm for filtering.

EKF is similar to WMEKF, $g_{\Delta r,k}^N(Z_k^m, X[\text{caret}]_{k/k-1})$ is the local derivative in EKF.

$$h_{\Delta r,k}^N(X_k) = r_{r,k-1} - r_{r,k-1},$$

$$\frac{\partial h_{\Delta r,k}^N(X_k)}{\partial x_k} = \frac{x_k - x_r - k_1 T v_{x,k}}{r_{r,k-1}},$$

$$- \frac{x_k - x_r - k_1 T v_{x,k}}{r_{r,k-1}} \quad (3)$$

$$\frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{x,k}} = k_1 T \frac{x_k - x_r - k_1 T v_{x,k}}{r_{r,k-1}},$$

$$- k_1 T \frac{x_k - x_r - k_1 T v_{x,k}}{r_{r,k-1}} \quad (4)$$

To replace x with y or z (including marks) in (3) and (4), we may get

$$\frac{\partial h_{\Delta r,k}^N(X_k)}{\partial y_k} \text{ or } \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial z_k} \text{ and } \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{y,k}}$$

$$\text{or } \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{z,k}}.$$

In which:

(1) $k_1 = N_k, k_2 = 0$. (2) $k_1 = N_k + I_k, k_2 = N_k$. (3) $k_1 = N_k + I_k + J_k, k_2 = N_k + I_k$.

Three values of k_1 and k_2 form a 3×6 matrix $g_{\Delta r,k}^N(Z_k^m, X[\text{caret}]_{k/k-1})$, where each 1×6 submatrix— $g_{\Delta r,k}^N(Z_k^m, X[\text{caret}]_{k/k-1})$ is written as:

$$\left[\frac{\partial h_{\Delta r,k}^N(X_k)}{\partial x_k}, \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial y_k}, \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial z_k}, \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{x,k}}, \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{y,k}}, \frac{\partial h_{\Delta r,k}^N(X_k)}{\partial v_{z,k}} \right]_{x_k = \hat{x}_{k/k-1}}$$

And $R_{\Delta r,k} = \text{diag}[N_k \sigma_{\Delta r}^2, I_k \sigma_{\Delta r}^2, J_k \sigma_{\Delta r}^2]$.

2.5 The Application of Filtering Formulae

WMEKF algorithm is introduced as follows:

$$K_k = P_{k/k-1} g_k^T [g_k^T P_{k/k-1} g_k^T + R_k]^{-1}$$

$$P_{k/k} = [I - K_k g_k^T] P_{k/k-1}$$

$$\hat{X}_{k/k} = \hat{X}_{k/k-1} + K_k [Z_k^m - h(\hat{X}_{k/k-1})]$$

$$\hat{X}_{k+1/k} = \Phi \hat{X}_{k/k}$$

$$P_{k+1/k} = \Phi P_{k/k} \Phi^T + Q_k$$

where: g_k is $g_k(Z_k^m, \hat{X}_{k/k-1})$. Let: $g_k(Z_k^m, \hat{X}_{k/k-1})$

$$= [g_{\Delta r,k}^T(Z_k^m, \hat{X}_{k/k-1}), g_{\Delta y,k}^T(Z_k^m, \hat{X}_{k/k-1})]^T$$

$$R_k = \begin{bmatrix} R_{\Delta r,k} & 0 \\ 0 & R_{\Delta y,k} \end{bmatrix}$$

$$h(\hat{X}_{k/k-1}) = [h_{\Delta r,k}(\hat{X}_{k/k-1}), h_{\Delta y,k}(\hat{X}_{k/k-1})]^T.$$

The original values of the filter are chosen by using the following way.

The estimated distance $R[\text{caret}]_0$ between emitter and receiver can be predicted according to the maximum effective distance of receiver. At the same time the target's height $z[\text{caret}]$ can also be estimated. We choose:

$$\hat{x}_0 = \sqrt{\hat{R}_0^2 - \hat{z}^2 \cos^2 \beta_0} + x_r,$$

$$\hat{y}_0 = \sqrt{\hat{R}_0^2 - \hat{z}^2 \sin^2 \beta_0} + y_r, \hat{z}_0 = \hat{z} + z_r,$$

$$(\hat{v}_{x0}, \hat{v}_{y0}, \hat{v}_{z0}) = 0.5(v_{\max}, v_{\max}, v_{\max})$$

$$P_{0/0} = \text{diag}[3(\text{km})^2, 3(\text{km})^2, 3(\text{km})^2,$$

$$(100\text{m/s})^2, (100\text{m/s})^2, (100\text{m/s})^2].$$

3. Computer Simulation Test

3.1 Test Conditions and Environment

Receiver station address is (30,0,0) km.

Initial tracking point is (50,60,10) km.

Maximum speed is (-500,-500,0) m/s.

Path (1) (-300,-300,0) m/s; (2) (-450,0,0) m/s; (3) (0,-450,0) m/s.

$\sigma_p = 2$ mrad, $\sigma_{\Delta r} = 5$ m, $q_x = q_y = 20$ m/s², $q_z = 10$ m/s².

$R[\text{caret}]_0 = 70$ km, $z[\text{caret}]_0 = 15$ km, 30 times of Monte Carlo test.

3.2 Analyses of Test Results

a. Location and tracking effects vary from paths. Path (3) reaches best result because of its changeful distance and azimuth. Location effect of path (1) is nearly the same as that of path (3) except for larger square deviation. Nevertheless its location errors at x or y axis and R direction are still limited within 1 km. Because distance between emitter and receiver has little change in path (2) so we fail to locate and track the moving emitter in this path.

b. When a receiver locates and tracks a 3-D emitter moving at a constant speed only by using distance and azimuth measurements, the maximum error is in the height while errors in x or y axis and the R direction will never diverge in three typical target paths. It is proved by the results that location and tracking technique based on distance difference and azimuth measurements is valuable when the target's height needs not accurate location.

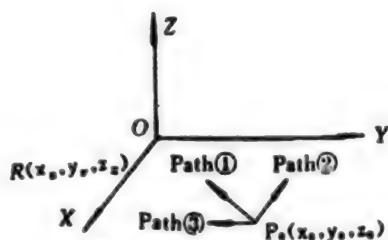


Figure 1. Target Path

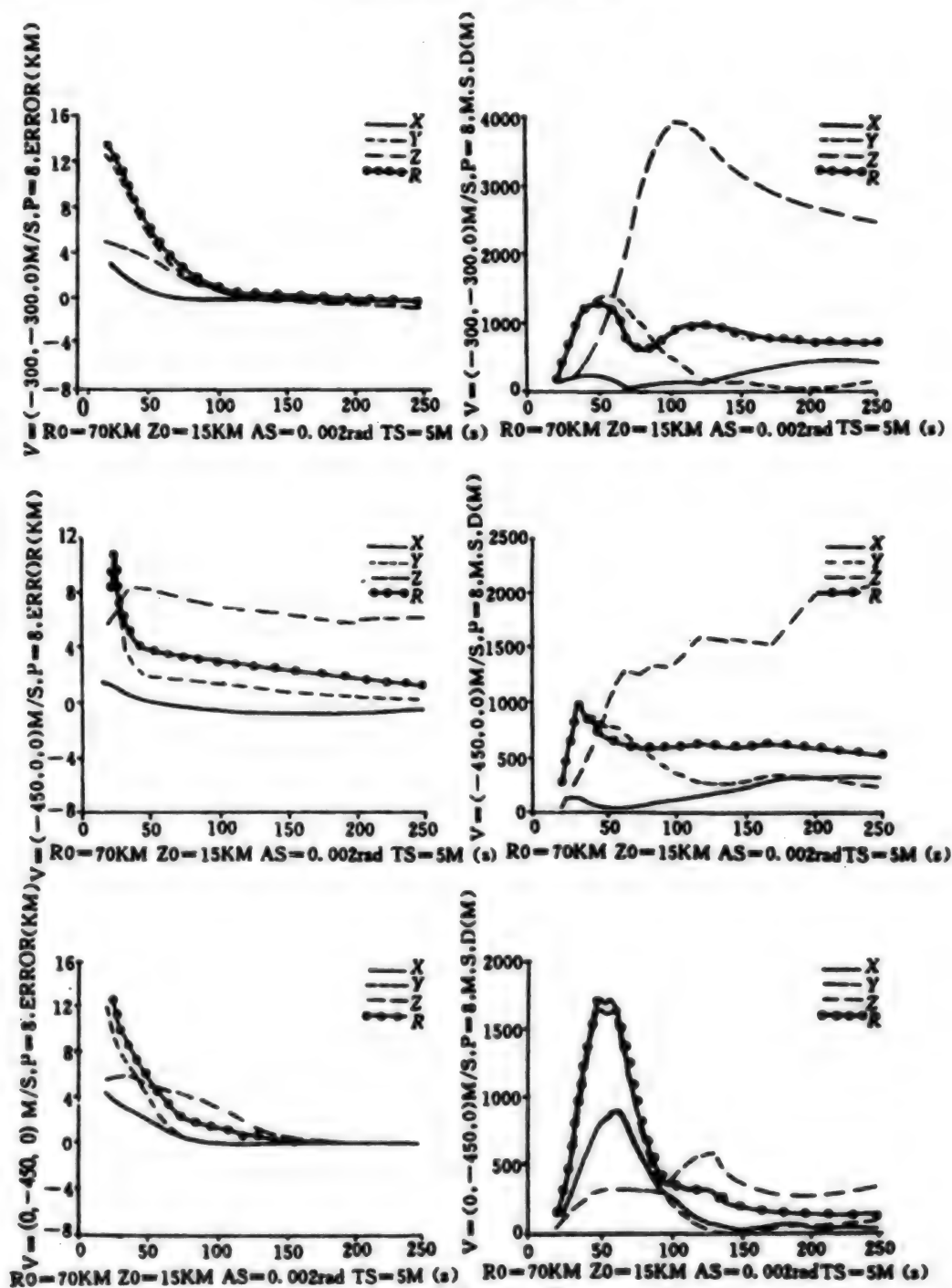


Figure 2. Tracking Error

4. Conclusion

The way to track a 3-D moving target by using a receiver without elevation angle measurements has put forward the development of passive location and tracking technique and has widened the range of SOPLAT. From simulation results we see that the location effect is good

in paths where the emitter's azimuth and distance are changeful, which shows that height message can be extracted from variable distance and azimuth measurements. Therefore some equipments in the receiver may be simplified and R station will become more flexible. In a word the way proposed in this paper is useful in ECM environment.

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Detection Theory of Self-Organizing Feature Map, Its Application

40100073B Changsha GUOFANG KEJI DAXUE
XUEBAO [JOURNAL OF NATIONAL UNIVERSITY
OF DEFENSE TECHNOLOGY] in English
Vol 16 No 1, Mar 94 pp 9-15

[Article by Wu Yanyan, Huangfu Kan, Zhou Liangzhu, and Wan Jianwei of the Department of Electronic Technology, NUDT, Changsha, 410073; MS received 15 Jun 93]

[Text]

Abstract

Artificial neural net models have been studied for years in the hope of achieving human-like performance in the field of information processing. In the paper the learning rule of Kohonen self-organization feature map is modified in order to decrease the fuzziness on the edges of topological neighbors. Then with its associative memory function, we can realize the memory of the features of the input stochastic process, consequently the detection can be performed. We also describe the mathematical mechanisms of multi-dimensional detection, as its result high-accuracy performance can be derived.

Key words: neural net, target detection

1. The Optimized Learning Rule Based on Kohonen Self-Organizing Feature Map

There is no doubt all kinds of artificial neural net come from the research results of the neural physiology. An important organizing principle of sensory path-ways in the brain is that the placement of neurons is orderly and often reflects some physical characteristics of the external stimulus being sensed. Furthermore, although much of the low-level organization is genetically pre-determined, it is likely that some of the organization at higher levels is created through sensory experience. Kohonen presents his algorithm to produce what he calls self-organizing feature map similar to those occurring in the brain.

Figure 1-1 shows a two-dimensional Kohonen self-organizing system with N input nodes to M output nodes. Here's his rules:

1) Similarity Matching:

$$\|X(t) - W_c(t)\| = \text{Min}\{\|X(t) - W_i(t)\|\}$$

2) Updating

$$W_c(t+1) = W_c(t) + \alpha(t) \cdot [X(t) - W_c(t)]$$

for $i \in \text{NE}(t)$.

$$W_c(t+1) = W_c(t) \quad \text{other}$$

$\text{NE}(t)$ is the set of nodes considered to be in the neighborhood of node c at time t . The neighborhood starts large and slowly decreases in size over time. The term $\alpha(t)$ is a gain term that decreases in time.

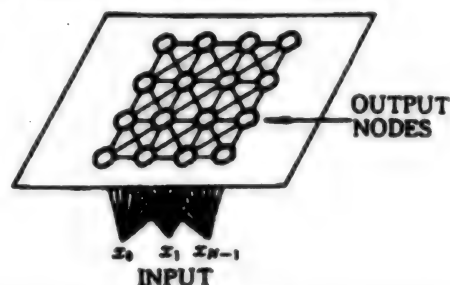


Figure 1-1

According to the rules, training samples are presented one by one at the input and the learning process is repeated until the gain term is reduced to zero. The weights between the input and output nodes converge. The fixed weights will coincide with the centers of gravity of the input space with respect to weighting function of probability distribution of the input vectors.

The initial stage of the training procedure is important for specifying cluster. Now let's consider the mathematical process of this stage. It can be tested that the adaptation equation

$$d[W_c(t)]/dt = \alpha(t) \cdot [X(t) - W_c(t)]$$

has the solution:

$$W_c(t) = \text{EXP}(-\alpha(t) \cdot t) \cdot [W_c(0) + \alpha(t) \cdot \int_0^t \text{EXP}[\alpha(\tau) \cdot \tau] \cdot x(\tau) d(\tau)]$$

when the conditions $|t \cdot d\alpha(t)/dt| \ll |\alpha(t)|$ and $d\alpha(t)/dt \geq 0$ are met, if $\alpha(t) = 1 - t/N$. (N represent the whole training times.) Then the above conditions are satisfied.

Ignoring the small random values of weights, we get:

$$\begin{aligned}
 W_i(t) &= (1 - t/N) \\
 &\cdot \sum_{\tau=1}^t \text{EXP}[(\tau - t)(1 - (\tau + t)/N)] \cdot X(\tau) \\
 &\approx \sum_{\tau=1}^t \text{EXP}(\tau - t) \cdot X(\tau) \quad t \ll N, i \in NE(t) \\
 W_i(1) &\approx X(1) \\
 W_i(2) &\approx \text{EXP}(-1) \cdot X(1) + \text{EXP}(0) \cdot X(2) \\
 W_i(3) &\approx \text{EXP}(-2) \cdot X(1) + \text{EXP}(-1) \cdot X(2) + X(3) \\
 &= \text{EXP}(-1) \cdot W_i(2) + X(3) \\
 W_i(t) &\approx \text{EXP}(-1) \cdot W_i(t-1) + X(t)
 \end{aligned}$$

We see on the initial stage, the weights tend to the gravity center of the input space by an exponentially weighted moving average of $X(t)$. However, the weights to all nodes in the larger neighborhood will get the same evolution according to the above formula by each iteration. Thus the fuzziness on the edges of topological neighbors which response to different kinds of input pattern may produce. We modify the updating rule:

$$\begin{aligned}
 W_i(t+1) &= W_i(t) + \alpha(t) \cdot \text{EXP}[-\sqrt{|i-c|/2}] \\
 &\cdot [X(t) - W_i(t)] \quad \text{for } i \in NE(t) \\
 W_i(t+1) &= W_i(t) \quad \text{other}
 \end{aligned}$$

$|i-c|$ represents the distance between the output node i and its topological center c .

Here the weights are then proportionately modified according to how far away from the topological center, so that the fuzziness on the edges of different neighbors is decreased. Improved clustering ability thus can be got.

Adaptation stops after training. Output nodes will be ordered in a natural manner. The weights are organized such that topologically close nodes are sensitive to inputs that are physically similar. Detection would be fulfilled under the supervision of the response region on the feature map when the detection sample is presented at the input.

2. The Estimation of the NN Detection Performance

As for detection problem, we have only two response regions on the feature map corresponding to the two cases of having target or not. According to the similarity matching rule, the cluster is specified by the Euclidean distance. That is to say the threshold seems likely to be the mid-point of two centers of the probability distribution of input samples.

See Figure 2-1. To simplify our analyses, we suppose:

Firstly, the elements of input vector are independent of each other, i.e., ignoring their correlations in time.

Secondly, the shapes of the probability distribution of the two cases are approximately the same.

Thirdly, the trained neural net is in equilibrium for both cases.

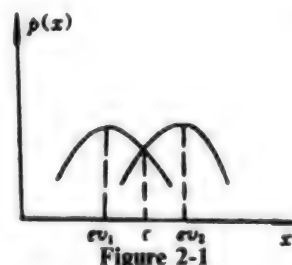


Figure 2-1

Thereby NN has two centers (i.e., ev_1, ev_2) which are symmetric about the threshold C . It's easy to get:

$$\begin{aligned}
 P_f + P_d &= 1 \\
 (P_f + P_d)^M &= C_M^0 \cdot P_f^M + \dots + C_M^{M/2-1} \cdot P_f^{M/2+1} \\
 &\quad \cdot P_d^{M/2-1} + C_M^{M/2} \cdot P_f^{M/2} \cdot P_d^{M/2} \\
 &\quad + C_M^{M/2+1} \cdot P_f^{M/2-1} \cdot P_d^{M/2+1} \\
 &\quad + \dots + C_M^M \cdot P_d^M
 \end{aligned}$$

We apply 1/2 criterion to make the decision,

$$\begin{aligned}
 P_{ff} &= C_M^0 \cdot P_f^M + \dots + C_M^{M/2-1} \cdot P_f^{M/2+1} \\
 &\quad \cdot P_d^{M/2-1} + P_f \cdot C_M^{M/2} \cdot P_f^{M/2} \cdot P_d^{M/2} \\
 P_{dd} &= C_M^M \cdot P_d^M + \dots + C_M^{M/2+1} \cdot P_f^{M/2-1} \\
 &\quad \cdot P_d^{M/2+1} + P_d \cdot C_M^{M/2} \cdot P_f^{M/2} \cdot P_d^{M/2}
 \end{aligned}$$

Here, P_f, P_d represent respectively the false alarm rate and the detecting rate of one-dimensional testing.

P_{ff} , P_{dd} represent respectively the false alarm rate and the detecting rate of m -dimensional testing.

As for term $C_M^{M/2} \times P_f^{M/2} \times P_d^{M/2}$, considering the false alarm rate, we weight it by P_f .

For example, if $M = 12$, $P_f = 0.1$, then we get $P_{ff} = 10^{-4}$, so high accuracy performance is expected through such multi-dimensional joint decision by NN.

To support our analyses, we design a group of simulation experiments, of which the same numbers of training samples are independently produced and are symmetrically distributed about a threshold according to some probability density function, referring to Figure 2-1. Table 2-1 gives the simulation results. Figure 2-2 illustrates the probability distributions of the weights of two response

Table 2-1

Dim.	T	Pee(ES) $\times 10^{-4}$	Pee(NN) $\times 10^{-4}$
Gaussian distribution	$M=6$	0.7	634
		0.8	406
		0.9	250
		1.0	148
		1.1	84
	$M=9$	0.7	430
		0.8	250
		0.9	138
		1.0	72
		1.1	36
Rayleigh Distribution	$M=12$	0.6	396
		0.7	204
		0.8	97
		0.9	43
		1.0	18
	$M=12$	0.25	1095
		0.35	559
		0.45	260
		0.55	115
		0.65	43

Pee(ES) is the estimation of false decision rate

Pee(MM) is the average false decision rate on NN

T is the half distance between the centers of two cases.

regions on the trained feature map respectively. Our analyses seem to be reasonable. Because of the symmetric distribution of the training samples and their equal opportunities to be learned, the false decision rate for each case is approximately the same, thus is approximate to their average values shown in the table. The performance is therefore relatively stable. This way suggests what we called equal-risk criterion. The reason for the better results than the estimations is because of the fuzzy decision mainly corresponding to $C_M^{M/2} \times P_f^{M/2} \times P_d^{M/2}$ as $P_f \ll 1$. Better performances are expected as the fuzziness on the edges of topological neighbors is decreased. Therefore further optimization of the algorithm still has practical significance. Here the essential conclusion is that high-accuracy performance can be achieved by NN detection, also the detection is nonparametric because of the self-organizing learning process.

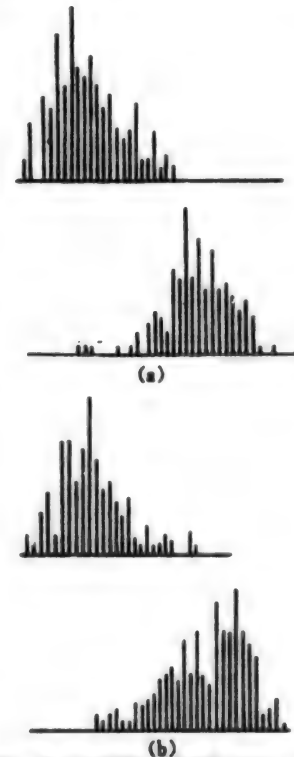


Figure 2-2. The Probability Distribution of the Weights of Two Response Areas on the Trained Feature Map

(a) The Gaussian case and its symmetric one; (b) the Rayleigh case and its symmetric one

3. Application of NN Detection in Radar MTD System

As one application, we construct NN detection unit in Radar MTD system in the place of the general cell averaging CFAR. Figure 3-1 shows such a digital moving target spectrum processing unit. Before the detection can be applied, the knowledge of the environment must be learned. Here $K + 1$ points DFT correspond to $K + 1$ filters, the number of the pulse accumulation is M , and N

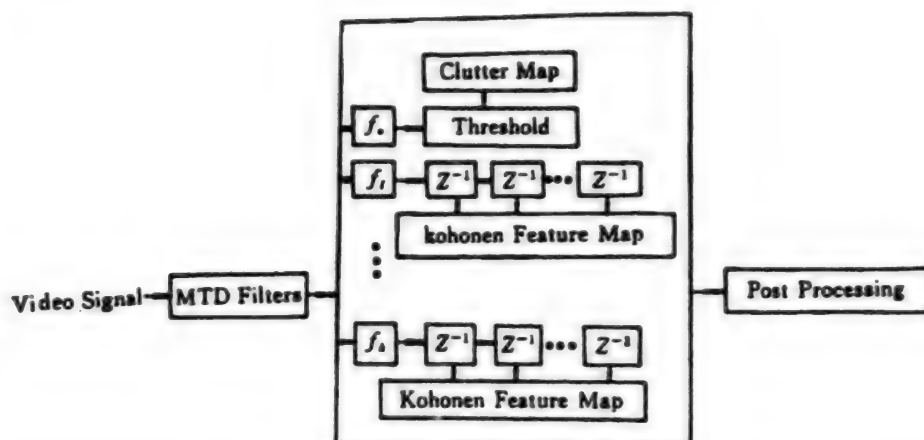


Figure 3-1. NN Detection Unit

neighboring range cells are considered to belong to the same environment. Seeing Figure 3-2, if we slip one sample point each time, $M - K$ outputs will be got through each filter for every range cell. We made them a sample vector of $M - K$ dimension. We collect our sample set on N neighboring range cells, then we get the sample set X_{ji} ($i = 1, \dots, N, j = 1, \dots, M$). Except for zero channel, the outputs of which we keep the clutter map detection, the other K filters will give K groups of such a sample set that offer the samples of K frequency-ranges. We construct the reference samples by adding constant vectors to the sample vectors so as to cause the weights connecting to the nodes outside the clutter to distribute meaningfully. We present the sample sets and its references ones to train K Kohonen feature maps at the same time. We just need to keep the distances of the two cases of training samples to keep CFAR.

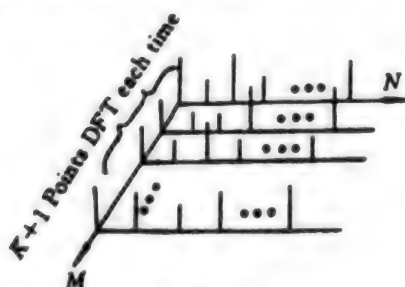


Figure 3-2

We illustrate the channel one's (i.e., f_1) detection performance under sea clutter environment in Figure 3-3. Here $M = 20, K = 8, N = 32$, the NN has 13 input nodes and 28 output nodes in lines. As a comparison, we also give the result of the generalized sign-threshold-detection with the same numbers of pulse accumulation which is also a nonparametric method. Obviously the performance of NN detection has 5 db or so improvement under the 10^{-6} false alarm rate, and is more sensitive to SNR.

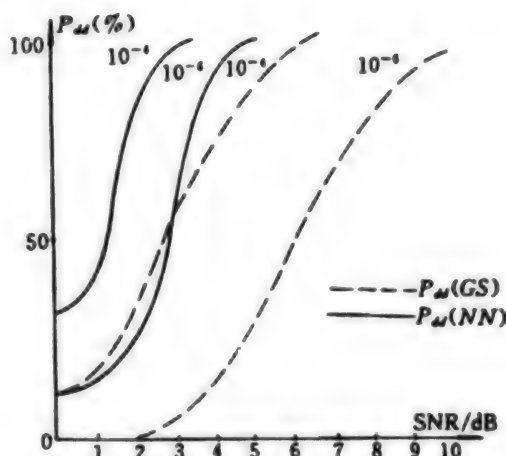


Figure 3-3

4. Conclusion

The high-accuracy performance is achieved through the multi-dimensional joint decision by NN on the bases of equal-risk training condition. In addition, the NN detection is nonparametric because of the self-organizing learning process.

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Factory Automation and Robotics

Developments in Leading-Edge Robotics Research Reported

Additional Details on BUAA's 7-Degrees-of-Freedom Robot

94P60303A Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
Vol 4 No 2, Feb 94 pp 21, 4

[Article by Zong Guanghua [1350 0342 5478]: "BUAA-RR 7-Degrees-of-Freedom Robotics Research Project Passes Acceptance Check and Appraisal"; cf. brief report with photo in JPRS-CST-94-002, 25 Feb 94 p 25]

[Summary] The 7-degrees-of-freedom robotics research project of Beijing University of Aeronautics & Astronautics Institute of Robotics Research (BUAA-RR) on 28 December 1993 passed the acceptance check conducted by the 863 Program 512 Main Topic expert group as well as a formal appraisal conducted by the China Aerospace Industry Corporation (CASC). Main technical indicators for this advanced robot are as follows: maximum lift weight: 2.5 kg; no. of joints: 7; joint dynamic range: +/- 170 deg for joints 1,3,5,6 and 7, +/- 105 deg for joint 2, +/- 165 deg for joint 4; joint maximum speed: 80 deg/s for joints 1 and 2, 115 deg/s for joint 5, 138 deg/s for joints 3 and 4, 204 deg/s for joint 6, and 318 deg/s for joint 7; maximum linear speed: 1000 mm/s; repeat positioning accuracy: +/- 1 mm; operating space: 2.4 cubic meters; drive mode: rare-earth permanent magnet DC motor; operating modes: demonstration cassette and keyboard human-machine interactive; control mode: real-time kinematic continuous-track control; unique functions: can "autonomously" avoid obstacles; exterior dimensions: 230 mm long x 550 mm high x 1430 mm wide; gross weight: 85 kg (excluding controller).

Bionic Ultraprecise Planar Actuator, Controller

94P60303B Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
Vol 4 No 3, Mar 94 pp 14-16

[Article by Sun Lining [1327 4539 1337], An Hui [1344 6540], and Cai Hegao [5591 7729 4108] of the Robotics Research Institute, Harbin Institute of Technology, Harbin 150006: "Research on, Application of Bionic Ultraprecise Planar Actuator and Controller," supported by grants from 863 Program and State Education Commission's Ph.D. Fund; MS received 4 Dec 93, revised 14 Dec 93]

[Abstract] A bionic ultraprecise planar actuator and HRPD-series controllers are presented. By combining the actuator with a general-purpose robot, a macro/micro manipulator system for precise assembly operations has been constructed. Main performance parameters follow: controllable run: +/- 5 mm; maximum step: 50 microns, minimum step: 0.01 micron, shift resolution: 0.01 micron; system frequency response: 200 Hz.

The actuator uses the model WTDS-I electrostrictive ceramic microshifter. The application and development prospects for the actuator are described.

Figures 1-4, not reproduced, show the following: the movement principle for the bionic planar ultraprecise actuator, a schematic of same, a photograph of the front panel of the model HRPD-II electrostrictive ceramic controller, and the same for the model HRPD-III. There are no tables.

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High-Flexibility, Ultrahigh-Spatial-Resolution Tactile Sensor Array

94P60303C Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese
Vol 39 no 6, 16-31 Mar 94 pp 561-563

[Article by Jia Yunde [6328 0061 1779] and Li Kejie [2621 4430 2638] of the Dept. of Mechanical Engineering, Beijing Institute of Technology, Beijing 100081: "Research on High-Flexibility, Ultrahigh-Spatial-Resolution Tactile Sensor Array," supported by grant from NSFC; MS received 10 Jun 93, revised 20 Sep 93]

[Abstract] The use of a transparent rubber waveguide to create a highly flexible version of the TIR-type (optical total internal reflection) ultrahigh-spatial resolution tactile sensor array [described in refs. 1-4] is introduced. Essential parameters of the sensor array are as follows: white elastic film thickness is 0.3 mm, transparent rubber waveguide thickness is 6 mm, minimum resolvable slot width for slotted tactile images acquired by this sensor array (i.e. spatial resolution) is 0.2 mm, and corresponding array density exceeds 50 x 50 tactile sensing elements per square cm.

Figure 1, reproduced below, show a schematic of the tactile sensor array. Figures 2-3, not reproduced, show a photograph of a tactile image of a 5-fen coin acquired by the sensor array and a graph of pressure vs deformation for three different diameters (8 mm, 10 mm, and 12 mm) of cylinder end faces as the contact surface. There are no tables.

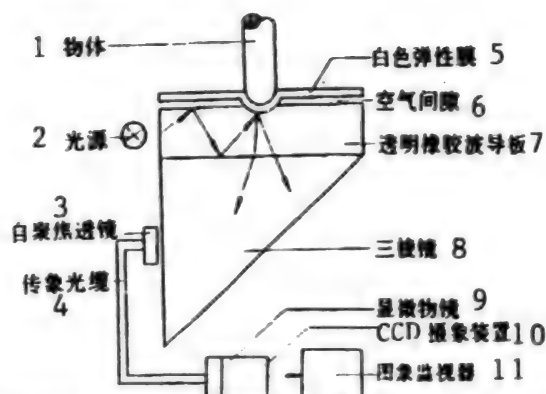


Figure 1: Schematic Diagram of Tactile Sensor Array Structure.

Key: 1. object; 2. light source; 3. self-focusing lens; 4. image-transmitting fiber optic cable; 5. white elastic film; 6. air gap; 7. transparent rubber waveguide; 8. triangular prism; 9. microscope; 10. CCD camera; 11. image monitor.

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Outdoor Mobile Intelligent Robot Certified

94P60303D Shenyang LIAONING KEJI BAO
in Chinese 26 May 94 p 1

[Article by Ke Wen [4430 2429]: "Outdoor Mobile Robot Moves Out from Laboratory"]

[Summary] The "outdoor mobile robot" jointly developed as an 863 Program (Intelligent Robots subject area) project by the CAS Shenyang Institute of Automation,

the University of Science & Technology for National Defense, and Harbin Institute of Technology passed expert acceptance check in Beijing the other day. The experts have appraised this intelligent robot to be world-class in terms of utilitarianism and technical performance. This outdoor mobile robot is intended to perform field duties and to be controlled by a [military] command car with a remote-control range of 10 km.

Microelectronics

Domestically Made CMOS 16-Bit Microprocessor Design Finalized

94P60299C Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS]
in Chinese 20 May 94 p 3

[Article by Guan Hui [4619 2585]: "Domestically Made CMOS 16-Bit Microprocessor"]

[Text] A domestic CMOS 16-bit microprocessor, model LC80C86, was recently developed by MEI's Institute 47. The LC80C86 uses a 2-micron Si-gate CMOS design, with a chip area of 45 square mm and an integration level of 10,000 gates. This is the highest-integration, highest-quality LSI microprocessor so far developed domestically. Testing results show that the LC80C86 circuit performance is completely identical to that of comparable foreign-made products. This IC meets mid-to-late-80s international standards and recently passed design finalization. The development of this IC has broken a foreign embargo, meets an urgent State need, and indicates the nation has ascended to a major new plateau in microcomputer LSI circuit technology.

Beijing University Develops 19-Stage Ring Oscillator with 190-ps Gate Delay

94P60299A Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS]
in Chinese 11 May 94 p 1

[Untitled photo report by Bao Xin]

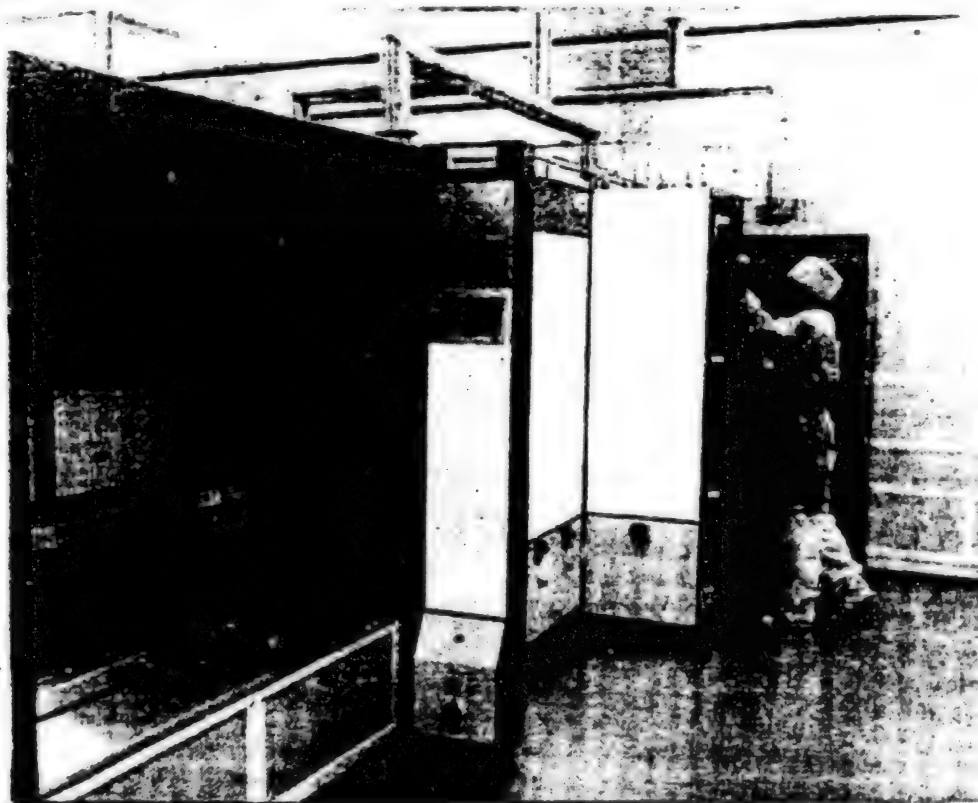
[Text] An Eighth FYP Key State Project undertaken by the Beijing University Institute of Microelectronics has realized a generational major breakthrough: development of a 19-stage ring oscillator with an average gate delay of 190 ps [picoseconds]. This forms a solid basis for future R&D of ASICs for very-high-speed computers, radio communications systems, and the like. The photo [not reproduced] shows a researcher testing the thickness of a thin film used in this very-high-speed integrated circuit [VHSIC].

Additional Details on Beijing University's 19-Stage Ring Oscillator

94P60299B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 16 May 94 p 1

[Untitled photo report by Bao Xin]

[Text] The Beijing University Institute of Microelectronics' Key State Project in R&D of CMOS/SIMOX-SOI [complementary metal oxide semiconductor/separation by implanted oxygen-silicon on insulator] ICs has realized a generational major breakthrough. From SIMOX material (2-inch [wafers]) meeting device requirements, the institute researchers have developed a 19-stage ring oscillator circuit with a single-gate delay of 290 ps [as published]. This material is mainly used in radiation-resistant ICs used in aeronautics and space. The accompanying photo shows the laboratory's main production room.



Latest Reports on Micromachine Development

Prof. Yang Yimin's Microactuators

94P60304A Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
Vol 4 No 3, Mar 94 pp 40-41

[Article by Li Botian [2621 0130 1131], Prof. and Asst. Director, South China Science & Engineering University, Guangzhou 510641: "On Yang Yimin's Microactuator Research Achievements"; MS receipt date not given]

[Summary] Guangdong Institute of Technology Prof. Yang Yimin [2799 1355 3046] is one of the leading domestic researchers in the area of precision micromachining, especially of microactuators. After being involved in a University of Tsukuba research project

entitled "New Microactuators and Microrobots" in 1986-88, he returned to China to continue his studies. Since then, he has developed a series of piezoelectric (as opposed to the conventional electromagnetic or electrostatic) microactuators, including a rectilinear microactuator [1], a bionic step-by-step rectilinear actuator [2], and a two-coordinate microactuator [3] with a controlled range of 50 x 50 microns, a drive force above 0.74 N and a bandwidth above 400 Hz. These microactuators have a unique architecture and a world-class (0.03 micron) controllable accuracy. They are excellent for ultrahigh-accuracy direct driving of 3A (factory-, home-, and office-automation) equipment. In general, Prof. Yang's microactuators have the following characteristics:

1. An integrated structure incorporating piezoelectric transducers (PZTs) and a circular-arc notched pivot. The PZT assemblies are small in volume (several

cubic mm to several tens of cubic mm), light in weight (several g to several tens of g), high in energy conversion efficiency (50 percent), high in output power (3500 kN/square cm), fast in response speed (several tens of microseconds), and high in controllable accuracy (0.01 micron).

2. Use of charge-control mode. This differs from the conventional voltage-control mode. Prof. Yang uses a controllable constant-current source to control the PZT assemblies; this provides a linear relationship between input and output.
3. Built-in sensors. This differs from conventional electromagnetic micromotors, which do not include built-in sensors. Specifically, Prof. Yang's microactuators are fitted with two semiconductor strained layers—one to detect displacement of the PZTs and one for temperature compensation—forming a Wheatstone bridge and together with an AD522 precision-measurement amplifier comprising a closed-loop control system.
4. Use of the EMM (Exact Model Matching) Method [4] for correction. This improves the dynamic performance of the microactuators and greatly reduces controller design and debugging time.

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Synchrotron Radiation X-Ray Lithography

94P60304B Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese Vol 39 No 6, 16-31 Mar 94 pp 572-573

[Article by Liu Zewen [0491 3419 2429], Tian Yangchao [3944 2254 6389] et al. of the State Synchrotron Radiation Laboratory (SSRL), University of Science & Technology of China (USTC), Hefei 230026: "Initial Experimental Results of Synchrotron Radiation X-Ray Lithography"; MS receipt date not given]

[Abstract] In our experiments, we used a domestically made PMMA [polymethyl methacrylate] positive photoresist (exposure time 10-20 min) and PCMS [para-chloromercuriphenyl sulfonate] negative photoresist (exposure time under 1 min) with a silicon wafer as the substrate. Based on various photoresist-layer thicknesses, we selected various photoresist spinning speeds (2000-6000 rpm). Our synchrotron X-ray lithography exposures were conducted in a vacuum case with a vacuum of under 3.7×10^{-4} Pa. We used a 1:1 proximity exposure method with a 0.8-micron metal mask absorber and a 2-micron silicon substrate. As observed with a scanning electron microscope (SEM), minimum line width for the corrugated pattern impressed on the PMMA is less than 0.2 micron (see Figure 1 below) and aspect ratio for a pattern of 5 x 5 rectangular pins exceeds 6:1 (see Figure 2 below). Minimum line width for a pattern impressed on the PCMS negative photoresist (see Figure 3 below) is 0.3 micron. These initial results demonstrate that the Hefei SSRL's X-ray lithography radiation source is suitable for micro-machining research and that the photoresists (made by the Wuxi Chemical Engineering Research and Design Institute) are suitable for research in deep-sub-micron X-ray lithography.

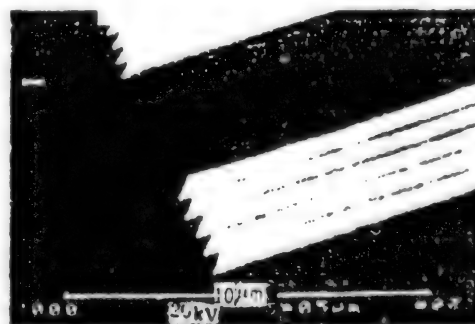


Figure 1. SEM micrograph of positive photoresist (PMMA) with minimum line width under 0.2 micron.

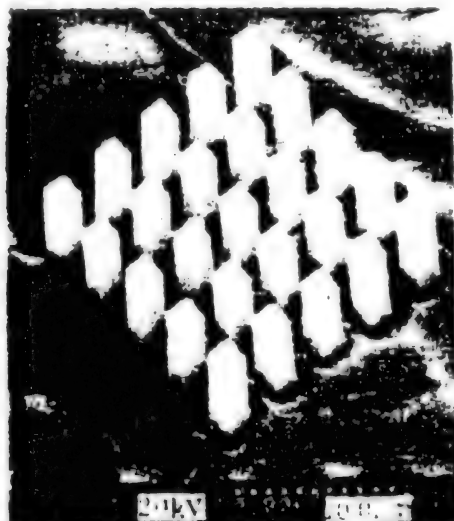
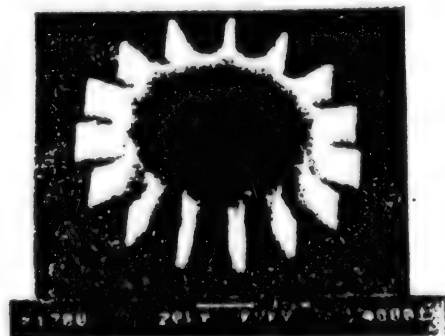


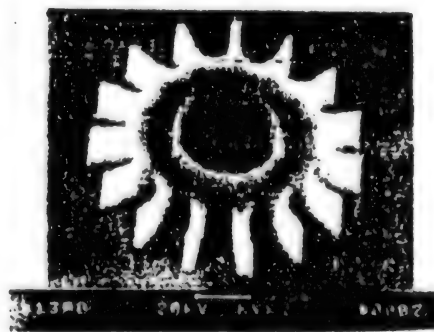
Figure 2. SEM micrograph of positive photoresist (PMMA) with aspect ratio greater than 6:1.



Figure 3. SEM micrograph of negative photoresist (PCMS) with line width of 0.3 micron.



(a)



(b)

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LIGA Deep Synchrotron Radiation Lithography

94P60304C Shanghai *GUANGXUE XUEBAO [ACTA OPTICA SINICA]* in Chinese Vol 14 No 4, Apr 94 pp 447-448

[Article by Tian Yangchao [3944 2254 6389], Fu Shaogun [0265 4801 6511] et al. of the SSRL, USTC, Hefei 230026: "Preliminary Study of Deep Synchrotron Radiation Lithography"; MS received 10 Nov 93]

[Abstract] The LIGA (Lithographie, Galvanoformung und Abformung) technique is based on a combination of deep-etch synchrotron radiation lithography, electroplating, and plastic forming or molding, among which processes the synchrotron radiation X-ray lithography is the key step. In this preliminary study, we present the results of our deep-etch synchrotron radiation X-ray lithography experiments. The results indicate that this lithography source is suitable for fabricating micromachines such as a fan with an outer diameter of 38-39 microns, an inner diameter of 20 microns, a blade length of 8 microns, a blade width of 2.7-2.9 microns, and a height of 25 microns, as shown in two LIGA-fabricated fan samples (Figure 1 a and b, below).

References:

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Telecommunications

New B-ISDN/ATM Concepts Implemented

BIP-ISDN: Unique Chinese Communications High Technology

94P60302A Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
Vol 4 No 2, Feb 94 pp 1-4

[Article by Zhong Yixin [6988 5030 0207], Asst. Director, Beijing University of Posts & Telecommunications (BUPT) and 863 Program Communications Topical Group Expert: "BIP-ISDN: A Unique Chinese Communications High Technology"; MS receipt date not given.

[Abstract] Proceeding from an analysis of fundamental trends in societal communications requirements and communications technical developments, a new domestic communications high technology development target is proposed: BIP-ISDN (Broadband, Intelligent, and Personalized Integrated Services Digital Network), similar to the IBC (Integrated Broadband Communications) concept advocated by the EC and the VI&P (Video, Intelligence, and Personalization ISDN) target and plan advocated by Japan, but uniquely suited to domestic conditions in China. The main contents of BIP-ISDN, scheduled to be implemented by 2000, are as follows: high-speed optical fiber transmission (OFT), broadband ATM [asynchronous transfer mode] switching, intelligent networks (IN), personal communications networks (PCN), multimedia communications terminals (MMT), and overall BIP-ISDN technology and an experimental network. The concept is shown schematically in Figure 2 below (Figure 1, not reproduced, is a production capacity model for the information society). There are no tables.

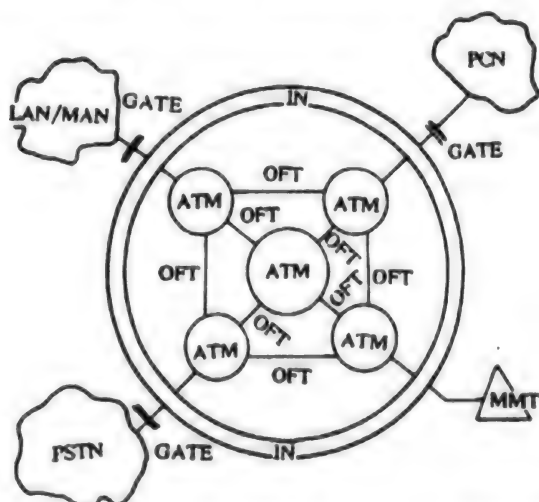


Figure 2: BIP-ISDN Model; LAN/MAN = local area network/metropolitan area network, PSTN = public switched telephone network.

No references.

ParaNET: Multigigabit Parallel ATM Ring Network

94P60302B Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
Vol 4 No 3, Mar 94 pp 1-6

[Article by Liu Bin [0491 2430], Wang Xinling [3769 2450 3781] et al. of the National Lab. of Switching Technology & Telecom. Networks, BUPT, Beijing 100088: "ParaNET: A Multigigabit Parallel ATM Ring Network," project no. 863-3-T-102-03 supported by grant from 863 Program; MS received 24 Nov 93, revised 22 Jan 94]

[Abstract] A parallel full-duplex multigigabit fiber optic ring network, ParaNET, is designed. ParaNET supports a peak transmission rate of 4.8 Gbps and operates with aggregate throughput of 20 Gbps. A parallel buffer insertion technique permitting traffic regulation with fairness is employed, and pipeline operations of FIFO [first in, first out] buffering queues are adopted for each access node (AN). As a result, distributed real-time-switched ATM cell delay can be minimized. Various priority levels are implemented by creating a multi-queue model. Dynamic bandwidth distribution is optimized among virtual logical subrings, so B-ISDN QOS [quality of service] protection is guaranteed for high-speed and/or delay-sensitive services. Intra-node low-speed (40 Mbps) parallel operations require only existing TTL and CMOS technologies. After a description of the ParaNET architecture, the modular structure and AN functions are then described. A parallel buffer insertion mode is discussed in detail, and some calculations of network performance are given. Additional specifications for ParaNET are as follows: ring-network coverage range = 300 km of fiber (MAN or WAN), maximum no of ANs = 64, inter-AN spacing = 30 km, peak transmission speed configurations are 16 STM-1 lines (= $16 \times 155.520 \text{ Mbps} \times 2 = 4.97664 \text{ Gbps}$) and 4 STM-4 lines (= $4 \times 622.080 \text{ Mbps} \times 2 = 4.97664 \text{ Gbps}$) using the SDH [synchronous digital hierarchy], peak throughput = 19.90656 Gbps, 64-AN buffer delay = 1600 ns, inter-AN insertion buffer queue length = 256 bits, maximum buffer delay of an ATM cell at an AN = 435.2 microseconds, maximum cell delay at an AN = 1935.2 microseconds, transmission delay for a 300-km fiber optic ring network = 1500 microseconds, and full-duplex maximum cell delay is less than 1 ms (average delay less than 500 microseconds). The authors have built a ParaNET experimental testbed in the laboratory, and have designed a corresponding high-speed parallel ring-network protocol, "Paratocol."

Figure 1, shown below, shows the topology of ParaNET. Figures 2-5, not reproduced, show the following: the UNI [universal network interface] logical frame structure for an ATM cell, the modular functions of the connecting points in the ParaNET ring network, multi-queue insertion for the parallel buffer, and pulse width modulation buffering of unequal read and write pulses, respectively. There are no tables.

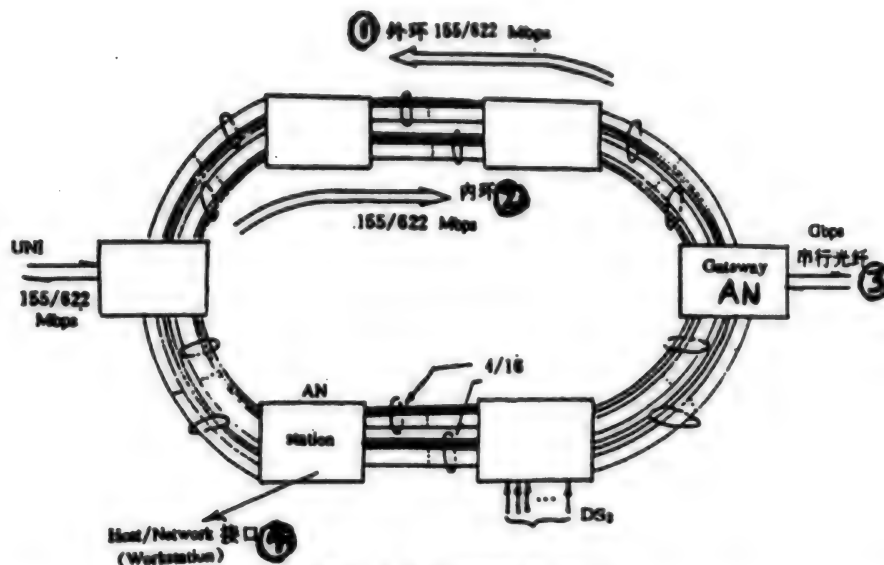


Figure 1. ParaNET Topology.

Key: 1. Outer ring 155/622 Mbps; 2. Inner ring 155/622 Mbps; 3. Gbps serial optical fiber; 4. connection point.

References:

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Additional Details on First Domestic Soliton Communications Experiment

94P60280A Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese
Vol 22 No 4, Apr 94 p 97

[Unattributed article: "2.5 GHz Optical Soliton Transmission"]

[Editorial Report] Additional details on Qinghua University's successful realization of China's first optical soliton transmission not already reported in an early brief report [see JPRS-CST-94-007, 3 May 94 p 19] are

given here. The range achieved by Prof. Zhou Bingkun's research group was 21 km. Light from the ultra-short-pulse soliton source, a gain-switched DFB [distributed feedback] laser diode (LD), was sent through a Fabry-Perot spectral window and chirped to the 2.5-GHz prf; pulse width was 18.0 ps and time-bandwidth product was 0.324. This constituted a near-transform-limited optical pulse. The pulses then passed through 1.48-micron- and 0.98-micron-wavelength LD-pumped erbium-doped fiber optical amplifiers (EDFAs). After amplification, the light was injected into a 21-km-long dispersion-shifted fiber (DSF) with an average dispersion parameter of 2.4 ps/km/nm. For an input optical pulse average power of 2.8 mW, output pulse width was 18.0 ps; and for an input optical pulse average power of 4.3 mW, output pulse width was 11.0 ps. This research project was supported by grants from NSFC and the State 863 Program.

First Fiber Optic Cable in Guizhou Province Nears Completion

94P60301A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 17 May 94 p 2

[Article by Fang Fang (2075 2455): "Guizhou Soon to Connect First Fiber Optic Communications Cable"]

[Summary] Guiyang (XINHUA)—Guizhou Province's first fiber optic communications cable—the Guiyang (eastern terminus) to Xingyi (western terminus) cable—will be operational by the end of the month. This 413-km-long, 40-million-yuan cable, jointly built by MPT and Guizhou Province, will supply 12,600 new long-distance telephone circuits. More important, the Guiyang-Xingyi cable forms a connecting line between the two largest fiber optic cable trunk lines in Southern China: the 4354-km-long, 1.07-billion-yuan, 140,000-circuit Fuzhou/Hangzhou-Guiyang-Chengdu cable, to be

completed in 1995, and the 987-km-long Nanning (Guangxi Province) to Kunming (Yunnan Province) cable, to be completed this year.

Civil Construction for Lanzhou-Urumqi Leg of Xian-Lanzhou-Urumqi Fiber Optic Cable Completed

94P60301B Beijing RENMIN RIBAO OVERSEAS EDITION. in Chinese 1 Jun 94 p 1

[Article by Qin Weidong [4440 5898 2639]: "Lanzhou-Urumqi Fiber Optic Cable Civil Construction Project Completed"]

[Summary] Lanzhou, 30 May (XINHUA)—Civil construction for the 2247-km-long Lanzhou-Urumqi leg of the Xian-Lanzhou-Urumqi fiber optic cable, a State Eighth FYP Key Project, has been completed. MPT experts have stated that this project was finished in record time for a cable of such length, thanks to the efforts of over 20,000 officers of the Lanzhou Military Region, who worked upwards of 16 hours per day in hot and windy desert and mountain terrain.

Shanghai-Based Sino-U.S Joint Venture to Produce VSAT Systems

94P60301C Shanghai WEN HUI BAO in Chinese 27 May 94 p 2

[Unattributed article: "Shanghai to Produce Satellite Communications Systems"]

[Summary] China's first joint venture dedicated to manufacturing and developing satellite communications systems—Shanghai-Hughes Network Systems Ltd.—was formally established in Shanghai yesterday. This joint venture, organized by Shanghai Municipality communications authorities, will unite the strengths of six domestic organizations (Shanghai Broadcast Television Ltd., Shanghai Jiaotong University's S&T Development Co., the Shanghai Municipal P&T Management Bureau, MPT First Research Institute's Communications Science & Technology Enterprises Corp., Shanghai S&T Investment Ltd., and the Shanghai Broadcasting Equipment Plant) with those of the U.S. firm Hughes Network Systems Ltd. At a press conference to announce the formation of this joint venture, the Hughes Chairman of the Board stated that his firm will invest \$100-150 million in Shanghai during the next few years. The \$8.8 million Shanghai-Hughes Network System Ltd. joint venture will set up in the Pudong New Area's Golden Bridge Development District a plant to manufacture, develop, and market VSAT (very-small-aperture terminal) satellite communications systems. This plant, which will be formally operational by the end of the year, will have an annual production capacity of 2000 remote terminals, with a part of the output to be exported. The joint venture will also manufacture HUB (main station) and NCS (network control systems) products, and take on network engineering and product maintenance

projects. The joint venture will utilize Hughes satellite communications production technology imported from the U.S., which will complement the domestic strengths of the aforementioned six organizations.

Latest Reports on Information Highway

China, Too, Paves Data Superhighway

40100082A Beijing CHINA DAILY (BUSINESS WEEKLY), in English 13 Jun 94 p 1

[Text] China is speeding up the construction of its own information superhighway—the Three Golden projects.

Ji Tong Communications Co Ltd, a shareholding company set up last September, is in charge of the Golden Bridge and Golden Customs projects.

Golden Bridge will be a national public economic-information network linking 500 cities and more than 10,000 information resources including large enterprises, institutes and government departments.

Ji Tong will soon start construction of the network's main centre and branch centres in 20 large cities, said Lu Shouqun, president of Ji Tong.

Golden Customs, whose goal is paperless foreign trade, will be in operation before the end of the year, he revealed.

Ji Tong is co-operating with Great Wall Computer Group Co and IBM Corp of the U.S. to conduct pilot works for the Golden Card project in 10 coastal cities, which aims to replace cash with electronic money-credit cards.

Lu said Ji Tong will also co-operate with the Ministry of Radio, Film & Television to build and operate multimedia cable TV networks.

The cost of building this information infrastructure will be enormous. Lu said Ji Tong will raise capital through various channels, including foreign funds.

Ji Tong is also actively seeking cooperation with foreign firms, he said.

It has established a \$30 million joint venture with BellSouth Corp, an American regional telephone company, to engage in telecommunications and cable TV network projects.

Ji Tong signed an agreement with IBM to set up a multimedia information network research and development company to provide technical support for the Three Golden projects.

The investment for the joint venture's first stage is \$10 million. Both sides will inject more money in the future.

Ji Tong has two more joint ventures, with companies from Malaysia and Hong Kong.

Each day Ji Tong deals with five to eight multinational corporations eager to participate in building China's ambitious information networks.

Lu said the government hopes the Three Golden projects will stimulate the development of domestic information and electronics industries.

China will import some equipment, but most will be supplied by domestic manufacturers and joint ventures.

Foreign companies with high technologies are welcome to co-operate with domestic producers.

Ji Tong will choose some large and medium-sized State enterprises to set up its production bases, Lu said.

Lu will soon go to the United States, Germany and France to inspect their progress in developing information superhighways.

Telecoms Work will be Hastened

40100082B Beijing CHINA DAILY (BUSINESS WEEKLY) in English 13 Jun 94 p 2

[Text] China will pick up the pace in its march toward modernizing its backward telecommunications by the year 2000, said a top government official.

Ye Qing, Vice-Minister of the State Planning Committee, said telecommunications have been a bottleneck in the national economy despite momentous growth in the last few years.

Major difficulties have been the lack of capital, technology and proper management, Ye said over the weekend at the International Conference on China's Telecommunications.

The conference, held in Beijing, was called to provide China with international expertise and perspectives in its determined effort to improve telecommunications. It was organized by the State Planning Committee and sponsored by Morgan Stanley & Co, Arthur Andersen & Co, Captel International and Baker & McKenzie.

Ye said China is receptive to international suggestions in drafting its telecommunications development strategy for the 1990s.

It is predicted that by 2000 domestic demand for telephones will soar to 30 million to 50 million.

The demand for fax machines will be 2 million to 3 million; for mobile phones, 4 million to 6 million; and for programme-controlled exchanges, 18 million to 23 million lines.

Wu Xiaolong, director-general of the Ministry of Electronics Industry's overall development department, said that in the remainder of this century priority will be

given to developing programme-controlled exchanges, fibre-optic networks, and mobile, satellite and microwave telecommunications systems.

He predicted that telecommunications industrial output will surpass 100 billion yuan, (\$11.5 billion) by 2000, over 15 percent of the country's entire electronics production.

By then, Wu said, the technical level of major telecommunications products in China will match the international norms of the mid-1990s. The Ministry of Electronics Industry has taken on the country's most ambitious development plan: to build an information superhighway.

The plan has three major parts.

First comes the Golden Bridge, a telecommunications network linking departments of the State Council with 30 provinces and autonomous regions, 500 cities, 12,000 large and medium-sized enterprises, 100 leading business groups and the country's key projects.

Second comes the Golden Customs, which will link authorities managing foreign trade, foreign exchange control and customs with foreign trade enterprises. This will speed up the handling of customs statistics, tax rebates, cash settlement and verification of licenses and certifications of country of origin.

The third is the Golden Card project in 10 coastal cities with the aim to replace cash with checks and credit cards.

Wu reiterated that China welcomes foreigners to invest in the domestic manufacture of telecommunications equipment.

Meocre Li, a senior manager with Arthur Andersen, said his auditing and consulting firm is working on the first direct listing on the New York Stock Exchange of a Chinese-incorporated power-generation company.

Pact to Update Beijing's Phone Network

40100082C Beijing CHINA DAILY (SCIENCE AND TECHNOLOGY SUPPLEMENT) in English 3 Jun 94 p 4

[Text] AT&T and the Beijing Telecommunications Administration (BTA) signed two contracts on 7 May, totalling more than \$20 million, for the supply and provision of the most up-to-date transmission and network management.

These two contracts will help the rapid development of the capital's telecommunications infrastructure.

Under these deals, AT&T will supply BTA with state-of-the-art SDH (synchronous digital hierarchy) fibre optical transmission equipment operating at 2.488 Gb/s (gigabits per second), and a set of advanced network management and surveillance systems to help monitor and manage their communications network.

SDH is an international transmission standard used for high-speed optical communications and allows multiple and diverse transmission systems to communicate with each other. At speeds of 2.488 Gb/s, the highest SDH rate commercially available today, the SLM 2000-16 system provided by AT&T is capable of handling more than 30,000 voice and data calls simultaneously over a single optical fibre transmission medium.

This sale represents a first for AT&T in its dealings with China. In the past, the sale of high-speed transmission equipment was controlled by COCOM and U.S. export controls; U.S. companies are now permitted to sell equipment such as SDH transmission systems operating at 2.488 Gb/s.

In addition, AT&T will also provide advanced and flexible DACS VI-2000 transmission equipment, a SDH-based system which offers all functions, such as combining multiple communications into a single channel for efficient routing and cross-connect capabilities allowing dynamic re-routing of calls, necessary for the modern "metropolitan junction network" Beijing has planned for itself.

The BTA network management contract, the first comprehensive sale of its type to China, includes several of AT&T's advanced operation systems designed to monitor and control the switching and transmission components or "elements" of a large communications network. These products include MFOS, a centralized switch surveillance and control system; Datakit, a high-speed data network connecting all the network management systems and network elements together; and TLM, a network surveillance system which integrates switching, transmission and signalling (SS7) network data elements into one centrally controlled display.

These new network management products will complement the already installed Transvu transmission surveillance and control system which AT&T provided to BTA earlier. Together, these products will provide BTA with

the tools necessary to fully manage all elements of its network, including switching, transmission, and signalling functions.

Upon its completion, Beijing will own the largest and most sophisticated digital transmission network in China, and the most advanced network management capabilities for the surveillance and control of its entire public telecommunications network. More importantly, Beijing will now be well positioned to offer advanced telecommunications services and have the flexibility to move forward with new services, having leapfrogged into a world-class, top-level transmission network.

The signing of the contracts for optical-transmission and network management is consistent with the intent and agreement originally set in the Memorandum of Understanding (MOU) signed last year and renewed recently.

"The signing of the two AT&T/BTA agreement signifies that the co-operation between AT&T, a world-renowned telecommunication and computer company, and Beijing, the capital of China, has entered a new state," said Zhang Ligui, director general of BTA. "The agreements we have signed are not merely business agreements. They further demonstrate our long-term friendly relations and partnership for the future. We believe that AT&T will continue its contribution to the development of China's economy and telecommunications infrastructure."

William Warwick, chairman of AT&T China Inc., confirmed: "We are firmly committed to supporting the future growth of telecommunications links between Beijing and the other cities, and to contributing to the speedy realization of the modernization of China's telecommunications network." Warwick added: "As this will be our first delivery of SDH technology to the capital of China since COCOM was dissolved and President Clinton lifted the export control on high speed transmission sales to China, we see these projects as an important milestone in building our relationship with the BTA."

National Developments

\$800 Million in Loans To Spark Power Sector

40100066A Beijing CHINA DAILY [ECONOMICS]
in English 18 May 94 p 2

[Article by Leo Chang]

[Text] The State Development Bank plans to ease capital shortages for big power projects by injecting 7 billion yuan (\$808 million) in loans into the fledgling sector.

The loans, this year's first batch, account for 36 percent of the 20 billion yuan (\$2.3 billion) the central government plans to arrange in bank loans this year.

Fund shortages could jeopardize the country's programmes to increase power generating capacity.

Power project investment this year is expected to reach 72 billion yuan (\$8.3 billion).

Funds raised by regional authorities and enterprises were first allowed in power construction in the mid-1980s as the central government could not satisfy the rising demand for energy.

This year, the State is picking up 40 percent of the costs, while regional authorities and enterprises cover another 40 percent.

Overseas cash from banks, governments and investors is expected to constitute another 10 percent.

The Ministry of Power Industry plans to have power plants producing 12 million kilowatts in capacity this year.

Power Supply Up But Still Short of Target

40100083A Beijing CHINA DAILY (Economics)
in English 1 Jul 94 p 2

[Article by Chang Weimin: "Power Supply Surges 11 Percent"]

[Text] The nation's supply of electricity grew 11 percent during the first half of this year, compared with the same period a year ago, the Ministry of Power Industry reported.

The growth reflects top priority given to the power industry's infrastructure.

Between January and 20 June, 409.8 billion kilowatt-hours were generated.

Production last year totalled 815 billion kilowatt-hours, 9.4 percent more than in 1992.

The latest statistics reflect fulfilling 46 percent of the 1994 plans for development in the electric power industry.

However, a ministry official said the plan of 890 billion kilowatt-hours for this year could be fulfilled.

The government has given priority to the industry, among other infrastructure sectors, so that 9 percent economic growth can be realized.

A total of 62.7 billion kilowatt-hours produced in the first half of 1994 came from hydropower, up 21 percent. Other power sources produced 337 billion therms, up 7.7 percent, and 5.534 billion kilowatt-hours of nuclear energy, an increase of 4.97 billion.

In the first half of last year, China's first nuclear power plant at Qinshan in Zhejiang Province, equipped with a 300,000-kilowatt generator, was still in trial operations.

The nuclear power plant at Daya Bay near Hong Kong, with two 900,000-kilowatt generators, went into operation early this year.

The official described production growth this year as stable.

The highest growth of 36 percent was created in the southern province of Guangdong. Growth in Hainan, Guizhou and Yunnan exceeded 20 percent.

However, the northeastern provinces of Liaoning, Jilin and Heilongjiang saw a much more modest growth of 3.6 percent.

Experts say that weak demand in these provinces may be related to the government's tough credit measures for curbing inflation.

Surveys will soon be started to confirm whether this is the true reason for a weak energy demand.

Demand in booming economic areas has been on the rise. From January through May in Guangdong alone, district supply failures numbered 1,120 plus, more than the same period last year.

In northwestern provinces and autonomous regions, production growth equalled about 10 percent.

Power failures have become a frequent occurrence in some Beijing districts. The city's capacity is estimated at 500,000 kilowatts less than what's needed.

Power shortages in the capital city should be alleviated by the end of next year, when new power plants in the Inner Mongolia Autonomous Regions come on line.

Both day and evening demand climbed sharply, but fell during the late hours. The gap between peak demands and lows widened.

Speeding Up Overhaul of Power Industry
946B0066A Beijing ZHONGGUO NENGYUAN
[ENERGY OF CHINA] in Chinese No 2,
25 Feb 94 pp 1-6

[Article by the Planning Department of the Ministry of Power Industry: "Issues Related to Accelerating Overhaul of Power Industry"]

[Text]

I. Reform and Requirement of Electric Power Production Plan

As the socialist market economy takes shape, the direction of planned reform is gradually switched toward medium- and long-term planning in order to better allocate resources for medium- and long-term use. Allocation of resources in the short term will make the market mechanism more effective. An annual plan becomes essentially a guidance in nature. The planning system becomes more target-oriented. On this basis, directive plan for next year's electricity production has become a target plan. It not only represents the target of the anticipated economic growth but also the expectation of the government and serves as a macroscopic guide. The electricity production plan was prepared based on the actual available production capacity and also by taking into account the fact that industry needs a productive and competitive environment with a comfortable margin.

In addition to projected targets, this key electric power industry production plan also includes a national resource target. It is an estimation of the portion of government investment for the purpose of macroscopic tuning by the government. It is different from the original electricity allocation system and covers a wider range. The national resource plan target for the four major power grids in northern, northeast, east, and central China is to give priority to key national industries in order to fulfill the promises of various policies. The cost of electricity should be set in accordance with the appropriate rules and regulations.

In 1994, the government issued its target electric production plans to six specific businesses and eight provincial (regional) electric utility companies (key electric utilities). The government also released national resource electricity production plans to all key electric utility companies (except for Guangdong and Hainan). These targets will not be reviewed by the government and are not binding to the electric utilities. They are primarily for information and guidance purposes only. After cancelling directive plans, the State Planning Commission authorized this Ministry to review planned targets of various key electric utilities. When targets to fulfill various policies are involved, different local electric utility bureaus may submit plans to the Ministry for special consideration. Each conglomerate is responsible for decomposing its own target internally. The amount of electricity sent to the power grid from each individual

power plant is to be negotiated between businesses according to market demand. It is to be regulated by economic means and administrative intervention should be minimized.

II. Thoughts Concerning Planning Based on Market Economy

(I) Face the market and strengthen macroscopic analysis.

To operate in a socialist market economy, we must focus on the market and totally give up the traditional approach and method.

1. We must be conscious of the market and firmly establish the concept of market demand. We have to face the market, analyze it and expand it. There are two kinds of market demands, i.e., the present demand and potential demand. There is a need to study whether the layout and status of production capacity is going to meet the varying demand of the market and how to expand the market. As far as electric power planning is concerned, first, we need to understand the present usage and load curve. A survey of shortage is required to analyze the nature and cause of shortage. We need to study the trend of power usage by surveying large users, understand any realignment of our industrial structure and changes in demand for agricultural and light and heavy industrial use, and study the trend of rural residential usage to open the rural market in order to build up a real demand forecast with convincing supporting evidence. In addition, it is also necessary to conduct market surveys on the existing capacity and potential, the scope of the reform and development work, and potentially available energy resources, capital equipment and environmental tolerance. Furthermore, we need to take both domestic and international market into consideration. Comparison studies should be done on other development projects throughout the world. The end result should be a practical and scientific development plan that is liberated from the old thinking.

2. In a planned economy, an electric power plan is primarily a technology plan. Such a plan is prepared from the viewpoint of technology, including method and means to estimate the load, build power sources and power grids. In a market economy, it becomes a plan of strategy and policy on the basis of the socio-economics. The focus is the study of measures and policies to make the strategic objectives a reality. Economic analysis must be stressed throughout the entire electric power development plan. On the basis of technical planning, we must provide a capitalization plan, a financial analysis and an economic assessment. We have to emphasize return of investment and stick to the principle that development, reform and profitability must be achieved as a whole. Different reform measures and policy requirements must

be presented and discussed openly in public to win the support from various authorities.

3. An electric power plan must also include a cost forecast and reform plan which is a critical component of the entire plan. We should take full advantage of the fact that cost of electricity is an excellent economic lever to regulate the demand, raise construction capital and improve operating condition and mechanism to make the plan work.

(II) An electric power plan must continuously investigate and absorb new thinking and experience while implementing our industrial policy.

The plan must completely abide by the policy that we will go with either hydroelectric, thermal or nuclear power plants depending on location. Considering the structure and unique features of our primary energy resources, priority should be given to hydroelectric power as a medium and long range plan. We should actively pursue thermal electric power and develop nuclear power to some extent. The following viewpoints need to be stressed.

1. Regarding giving priority to hydroelectric power. We should speed up hydroelectric construction to adjust our electric supply structure and treat it as a major project. Large, medium and small hydroelectric power projects should be planned simultaneously. The entire basin should be developed in series. We should encourage and support joint efforts to build hydroelectric power plants involving several regions and provinces. We have to prepare a plan for pumped-storage facilities and a plan to rebuild existing small hydroelectric power plants that have a total installed capacity of 7,000,000 kW that have serious defects.

Preparation should be initiated according to the adjusted design stage to make sure that hydroelectric projects can adapt to the overhauled bidding system and are compatible with the review process for key national construction projects. More conduits should be exploited to secure funding for this early stage work. We should attempt to commercialize this early stage work to accelerate its progress. We have to aim at having 40 million kW of installed hydroelectric capacity by the year 2000 with more than 25 million kW of large and medium facilities.

Versatility is a must. Medium and small hydroelectric power plants should be built in area that cannot be covered by a major power grid, if appropriate. Priority should be given to small- and medium-size hydroelectric power plants that play a pivotal regulating role to electrify the vast rural countryside and remote areas. It can be operated according to contract or in the form of a joint venture to protect the interest of every party involved.

2. Regarding thermal power. As far as the overall layout is concerned, thermal power plants should be constructed near coal mines, harbors and road intersections based on energy distribution and transportation constraints. In the meantime, power plants near coal mines must be well planned in order to implement the policy that both coal and electricity can be transported. Commercial electricity bases should be developed on the basis of market economy principles. As far as the structure is concerned, whether the province is energy abundant or deficient, as a development strategy, we have to consider constructing power plants locally versus at an energy base as a whole and come up with a corresponding price policy for coal and electricity. We must insist on installing high-performance, large-capacity, high-efficiency generators with peak shaving capability in newly constructed thermal power plants. Each electric power regulating agency must reinforce its administrative control over the implementation of our industrial policy and rigorously control the construction of medium- and low-pressure steam generator units. Especially within large power grids, they ought to be banned. In addition, focus should be placed on restructuring the electric power itself. For instance, our existing electric supply structure needs an immediate overhaul. As of the end of 1992, one-fourth of the total installed capacity of 166 million kW nationwide came from units below 25,000 kW. The average capacity per power plant was 46,000 kW. It is too scattered to be economical in scale. Low utilization of energy cannot be addressed. To this end, all departments must prepare a reconstruction plan to consolidate small plants into larger ones in the Ninth 5-Year Plan in order to restructure the electric power industry.

Environmental protection is an important issue to keep in mind as we develop thermal electric power. Any environmental protection plan must be included in the electric power plan. Environmental impact studies must be done according to government regulations. In addition to comprehensive utilization of powder, coal and ash to protect the environment in power plant construction, we should also actively explore clean coal burning technology for improved efficiency and cleaner environment. The Ministry is negotiating with the U.S. Department of Energy to jointly construct a demonstration Integrated Gasification-Combined Cycle (IGCC) power plant that employs a combined coal gasification and power generation cycle. We should try to finish it by the year 2000 so that we will be technically prepared to develop clean coal-burning technology in the next century. Furthermore, various organizations involved in the ongoing experimental studies on circulating fluidized-bed technology and desulfurization processes should work hard to keep their programs on track and maintain a good relationship with their foreign collaborators in order to gain some experience for the future.

3. As for nuclear power, the appropriate development policy is to plan for the intermediate term. Nevertheless, it must be done in a speedy manner at certain key locations. Coastal areas that are short of primary energy resources must deal with nuclear power planning as a strategic move. Nuclear power is very demanding in terms of technology and safety. It requires an enormous amount of work and highly specialized knowledge and a great deal of preparation. Appropriate authorities must assign this task to a specific organization. A special person is required to manage the bureau. By the year 2000, we must try to begin construction of nuclear power plants for Qinshan Phase II, Liaoning Nuclear Power, Guangdong Nuclear II and Zhejiang Nuclear II to bring our total nuclear power to 8-10 million kW.

(III) Utility companies must spend more effort in power grid planning (including urban grid reconstruction) to improve reliability and economy.

In particular, plans must be drawn to regulate the transportation of electricity between provinces and grids and to link up all the power grids nationwide.

1. Since our energy resources are distributed very unevenly and the market plays a basic role in the allocation of resources in a market economy, it can be expected that long-range, high-capacity transmission of electricity from large hydroelectric and thermal electric bases to high demand, energy-starved areas will grow at a very fast pace. Therefore, in addition to perfecting 500 kV and 330 kV major grids and 220 kV and 110 kV grids within each province and region, the plan should address the transmission of large amounts of electricity over a long range across provinces and power grids. Not only does technical feasibility need to be fully demonstrated but also economic factors must be considered so that the fundamental role of the market in the allocation of resources can be fully exploited.
2. Construction of the Three Gorges Hydroelectric Power Station, other large hydroelectric stations, energy bases and pit-mouth power plants creates a new opportunity for the development of our power grid. It also brings new issues that must be studied immediately. In the near term, in conjunction with the transmission of electricity from the Three Gorges Hydropower Station there are two issues to investigate in the area of power grid planning. One is that it is the right time to connect all the power grids in the nation. We should investigate various technical issues and implementation plans for this to become reality. The next issue is that the opportunity to create 1000 kV lines has arrived ahead of schedule. We should conduct studies to plan for the construction of this new voltage level. These two projects are being pursued by the Institute of Electric Power Planning and the Electric Power Research Institute under the direction of this Ministry.

3. A nationwide power grid and lines with higher voltage will bring us to a new stage in the development of power grids in China. This also imposes higher requirements for power grids being planned. Each electric regulating agency must take this situation into account and develop its own long-range power grid plan with new objectives.

4. Reconstruction of urban and rural grids must be put on the agenda to be included in the overall plan so that it can be implemented in steps.

(IV) Push for the reform of statistical data in order to provide reliable basis for market study to create a better electric power plan.

In a market economy, planning must be done to predict and guide us into the future. Conventional statistical methods must be reformed.

1. We propose to explore and establish a practical statistical indicator system and survey method that meets the need of our new national economy and reflects the unique characteristics of the electric power industry. It will provide a range of services, including statistical consulting, monitoring, forecast and analysis. Statistics will be done on an industry-wide basis, instead of by department, and will focus on economic benefits. Seven economic indicators will be included in the normal statistics. The numbers will be published quarterly in the Electric Power News. Economic activities of various industries will be included to ensure that the statistics is timely and accurate.
2. The State Planning Commission is going to establish a direct reporting system for key national projects starting from next year and specific arrangements have already been put in place. In addition, to better manage the use of foreign capital in electric power industry, the Ministry will establish a foreign investment information network. Leadership at every level must take statistical data seriously and include it in their daily routine. They need to strengthen their statistics organization, raise the quality of its personnel and improve their working conditions and pay to ensure that management at various levels can receive timely, accurate and comprehensive statistical data to make scientific decisions.

V. Industry should be capable of making its own investment and raising its own capital to achieve a balance between progress and capitalization.

The "decision" of the Third Central Committee meeting of the 14th Plenum called for the accelerated restructuring of our financial system and for an in-depth reform of our investment system. The government has decided to establish policy-oriented development banks to separate policy-oriented measures from commercial business, to gradually realize a risk responsibility system for corporate investment and bank loans, and to encourage and attract everyone to invest

in basic construction projects and to make local government responsible for local construction projects. In accordance to an overall plan, funding for major national projects will be raised by various policy-oriented banks, such as the national development bank, by issuing stocks and bonds and securing special low-interest-rate loans. A cooperation is solely responsible for the entire process of planning, capital raising, construction, production, operation, return of loan principal and interest, and appreciation of capital. This approach should solve the problems such as lack of long-range investment in the electric power industry, unstable supply of capital for major construction projects and low rate return of investment. At the same time, the Chinese Communist Party also released its "opinions on accelerating reform and growth of the electric power industry" based on principles governing a socialist market economy and the electric utility industry itself. According to a preliminary estimate based on goals for the year 2000, the electric utility industry needs to add 120-130 million kW of installed capacity in the next seven years and requires a static investment of 650 billion yuan (not including capital raised for the Three Gorges). It requires 150 million kW of generator units (including large capacity units that will be put in production ahead of time). On the basis of the present annual investment scale and channels, more than one-third of the capital is up in the air. There will be a shortage of 50 million kW of domestic equipment as well. Based on the requirements imposed by the government and the Chinese Communist Party, we must create more conduits to bring in more capital in order to solve the shortage of funds and equipment to develop our electric utility industry.

(I) Actively enhance the ability for an electric utility to borrow money.

According to the new accounting system, electric utilities on the provincial grid level should put all its available capital back into the industry. Based on a modern business standard, each provincial electric utility should define its assets, take care of its liabilities and assess its capital equipment in order to determine its shareholder equity. It should optimize its capital structure in order to push for a reform of the pricing structure. The next step is to plan to operate with borrowed money in order to create the condition to directly borrow money from a bank, to issue government-backed bonds, or to sell stock to raise money.

(II) Hopefully, the government policy will lean toward heavier investment in electric utility industry.

It is recommended that the national development bank lend more money to electric utilities over the long run and with increases year after year. The rate of increase has to be higher than the current level. Our assumption is that government provides policy-oriented loans to fund major hydroelectric and nuclear power plants and power grids. As for thermal power plants, in addition to

government loans, we should actively pursue commercial loans wherever and whenever it is possible. The key issue is to manage the pricing of electric power.

In order to enhance the peak-shaving and regulating capability of a large key power plant that supplies a grid serving several provinces, the government will provide a portion of its capital and invest it in the name of the power grid. The grid will then retain control and directly manage it on behalf of the government. Each regulating agency must carefully plan for the sources of capital for every project. Other power plants will be open for investment. All parties, including different levels of government, other industries and departments, are encouraged to participate in a variety of forms such as stock ownership, controlling interest and sole proprietorship.

(III) Carry out Vice Premier Zou Jiahua's [6760 1367 5478] instruction to separate the construction of power plants from that of power grids and to have the Ministry of Power Industry plan, build and manage all power grids.

The government will provide capital needed for the construction of power grids. The grid or provincial electric company will get a loan from a bank and is responsible for paying back both principal and interest. Additional funds may be obtained by charging fees to create a grid construction fund, charging a power grid construction fee, or issuing bonds backed by the government. The government owns the power grid. Its assets are legally possessed and used by the power grid company or provincial electric utility. It is responsible for the entire process, including planning, fundraising, construction, operation and return of principal and interest.

(IV) Expand the use of foreign capital to build the electric power industry.

A few years from now, the use of foreign capital will be expanded in a variety of forms. The proportion of foreign capital will be raised from 15 to 25 percent (including trading goods for goods) and imported equipment for newly-installed capacity will be increased from 20 to 30 percent. By the year 2000, the plan calls for \$25 billion of foreign investment and the importation of 45 million kW of equipment. The electric power industry has an unprecedented opportunity to use foreign investment. We must liberate our thinking, be practical, prudent and careful to allow the electric power industry to grow in a healthy manner with foreign investment. The following areas need to be addressed.

1. Take full advantage of loans given out by international financial organizations and governments. Try to expand the size of the loan in conjunction with international financial organizations. Since the reform, from 1979 to 1992, the total amount of foreign capital in electric power is close to \$12 billion (excluding trading goods with goods). It was primarily arranged by the government. The government borrowed the money and either it repaid the loan or the

electric power industry repaid the loan directly. Although the terms are very favorable for an international financial organization loan or a government-to-government loan, however, it requires a regional economic survey. In the past, it was not often used for projects inland. In recent years, many reform measures have been requested, more conditions have been attached to the loan, the amount of the loan is getting smaller, and the number of eligible projects is fairly limited. We are exploring the possibility of working with the World Bank and Asian Bank to expand the scale of financing. We hope the government will spend more money from the fourth phase of the Japan Overseas Cooperation Foundation loan in 1996 on electric power and direct more funds to the midwest on hydroelectric power, environmental protection, and energy conservation projects.

2. Create avenues for electric utilities to borrow money in the form of commercial loans and export loans. The electric power industry never used commercial loans in the past. We should try to create this avenue under the premise that the government will have ultimate control. The Ministry is prepared to apply to the government. Some electric companies are already using credit lines issued by local governments. Seller-financed loans have been used by the Huaneng International Electric Development Corporation. Recently, Hebei Electric Bureau, Hubei Electric Corporation and Heilongjiang Electric Company have been actively pursuing this approach. They have signed letters of intent with Siemens. This spirit should be encouraged. Moreover, different ways to guarantee loans need to be explored.
3. Directly seek financing in the international market. The State Council has agreed in principle to issue corporate bonds overseas to create an electric power fund. The Ministry is looking into offering stocks of companies that are highly profitable and well managed in foreign stock markets. Recently, the State Securities Commission has agreed to allow Huaneng Electric Corporation and Huaneng International Electric Development Corporation to sell stock of their own electric generating companies in New York. Let us hope that Huaneng will obey all government regulations and create a new way for us to raise money overseas.
4. Create more ways for foreign corporations to directly invest. Major foreign corporations, including the Asian Bank and the World Bank, are exploring various ways of participation, including joint venture, cooperative management, Chinese investment in the form of money or assets, and foreign investment in the form of money or equipment. On the basis of specific local situations, foreign corporations may be allowed to build power plants alone. The State Planning Commission has approved the construction of a power plant in Meizhouwan in Fujian by a foreign corporation. However, we need to control the price of electricity.

As we expand the use of foreign investment, we must particularly stress strong management. All local electric departments must plan well. All projects involving foreign investment must be included in the plan. All cases must be processed according to procedure. We have to make sure that the government has a controlling interest in or regulating power over all joint venture and joint management projects. We cannot promise a fixed rate of return and must insist on profit-sharing and risk-taking. Partners should be sought on a competitive basis following the principles of market economy. We need to understand the capital market worldwide and the credibility of foreign corporations to avoid making any blind decisions. We must estimate the price of electricity and balance the foreign exchange. The success of a project involving foreign investment is judged by whether the price of electricity is affordable so that the nation is not suffering a loss and whether we can balance the foreign exchange. In principle, we must try to balance the foreign exchange on our own. The exchange of renminbi to hard currency requires approval from the appropriate authority.

In conclusion, we must actively pursue different ways to expand the use of foreign capital. We should take advantage of favorable opportunities in the international financial market to promote the healthy development of our electric utility industry.

IV. Production, Basic Construction, and "Replacing Large With Small" Plan for 1994

(I) In 1994, the target is to generate 890 billion kWh of electricity nationwide, including 146 billion kWh from hydroelectric power, 736 billion kWh from thermal electric power, and 8 billion kWh from nuclear power. Compared to 1993, it will grow by 11.2 percent. Compared to the 815 billion kWh in the 1993 plan, the growth rate is 9.2 percent. It is essentially compatible with the 9-percent economic growth rate for the GDP.

Since the lifting of coal price controls in 1993, electric power to a large extent is becoming a market commodity. In 1994, the government canceled its electric power production plan. This creates the condition to market electricity in the market. To this end, we must establish a production management system with rules and regulations that meets the needs of a market economy. We have to focus on fuel management, including timely delivery of fuel, inspection of fuel quality, and storage. We have to coordinate production and collect feedback information in a timely manner to solve major production problems in time. Each organization must modify relevant parts of the original technical economic management regulations and economic responsibility system. The Ministry will also simplify its evaluation of various electric utilities.

(II) According to the national planning meeting, a total of 65.8 billion yuan will be invested in capital construction in the 1994 plan; 26.9 billion yuan from the government (including 3 billion yuan of foreign capital), 32.8

billion yuan from local capital and the Ministry, and 6.1 billion yuan from Huaneng. In 1994, 9.5775 million kW of capacity is scheduled to be put into production according to plan, including 2.8075 million kW of hydroelectric power and 6.77 million kW of thermal electric power. In 1994, the Ministry is scheduled to initiate 41 projects with a total capacity of 27.631 million kW, including eight hydroelectric projects totaling 7.782 million kW, and 33 thermal electric projects totaling 19.849 million kW. The plan includes a total of 24 preparation projects with a total capacity of 22.217 million kW, including two hydroelectric projects of 0.527 million kW and 22 thermal electric projects of 21.69 million kW.

(III) The major technology reform in 1994 is "to replace small with large." The plan calls for a total investment of 5.64 billion yuan, including 560 million yuan of bank loans and foreign investment and 5.08 billion yuan to be raised by industry locally. A total of 4.662 million kW is under construction. It is scheduled to replace 3.304 million kW of low and medium pressure units. In 1994, eight projects totalling 975,000 kW will be in production in 1994 to replace 851,000 kW of low and medium pressure units. Construction of nine projects totalling 1.216 million kW will begin in 1994 to replace 910,000 kW of existing capacity.

(IV) In order to accomplish the production goal set for 1994, all organizations are requested to pay full attention to the following issues.

1. Complete assignments to put power plants in production in order to keep the same level of large and medium plants in production as in 1993. Due to delay of funding and late delivery of equipment, a considerable number of projects are falling behind. Only 9.5775 million kW is scheduled for production in the national plan. However, from the standpoint of our national economy, it is not enough. To this end, the Ministry wants to put the total of 2.4425 million kW represented by Wuqiangxi Unit No. 1, Yantan No. 4, Dongfeng No. 2, Daqi Unit No. 1, Hasan Unit No. 3, Sanmenxia No. 1, Waigaoqiao and Liuzhou Unit No. 1 on the list of projects to complete. In addition to providing favorable conditions such as capital, equipment and transportation necessary to make it possible, all units must treat these projects as if they are going to be in production during the year. We have to put 12.02 million kW into production in 1994, which is close to the level we had in 1993.
2. Secure capital for construction. Local and industry investment makes up a large portion in basic construction and "using large to replace small" projects. The security of local funding is the key to completing the 1994 plan. Every grid and provincial electric company must take the initiative to contact local government to secure the collection, use and management of local electric construction fund. It should be treated seriously and included in the local budget to ensure that it will come through. In addition, an equipment reserve fund and a project spending plan

should be prepared according to progress and investment ratio. An investment schedule must be prepared with various local governments, investors and banks to ensure that funds are received according to proportion and nature of work in time. As for projects that use large plants to replace smaller ones, each company must view this as an opportunity to increase its production capacity, speed up technological progress, enhance corporate strength and promote its own growth. The inflow of capital is directly related to the survival of the business.

3. Work hard to expand the scale of power plants under construction. Every grid and provincial electric company must be well-prepared for newly initiated projects in 1994 and make sure that funding is secured. They should fight hard for approval from the government to begin another batch of construction projects. Due to the fact that the size of newly initiated construction projects has been dwindling in recent years, particularly only 9.835 million kW of new construction is underway in 1994, which is lower than the capacity that will go into production this year, construction of power plants is tapering off. This is the major problem in electric power development. To this end, we must increase the size of new construction in 1994. The Ministry proposes 41 new construction projects with a total capacity of 27.631 million kW and 24 preparation projects with a total capacity of 22.217 million kW. Many projects included in the new construction list are not ready for construction yet primarily because the depth of preparation is insufficient or the funding has not been secured. All electric companies must conduct thorough studies to find breakthrough measures to solve this problem.

Strategic Position and Issues of Energy in Shanxi, Shaanxi, and Inner Mongolia

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[Article by Peng Fangchun [1756 5364 2504] and Zhi Luchuan [2388 6424 1557] of the State Planning Commission and the Institute of Energy Research, Chinese Academy of Sciences]

[Text] There is an abundance of energy resources along the border of Shanxi, Shaanxi and Inner Mongolia. It is an extremely important national energy base that is recently being developed. The base is located in north central China and is also close to the load center in the east. It is more convenient to transport energy from this region. To date, it has more than one-fourth of the known coal reserves in the country. Furthermore, the coal is of high quality. The known natural gas reserve is over 100 billion cubic meters and it is capable of producing more than 3 billion cubic meters per year. The region will become a major natural gas-producing base. Coal and water resources are abundant in the region. It is

uniquely suited for building thermal electric power plants. At least 40 million kW of installed capacity can be planned. The following is a description of the scale, layout, issue and recommendations related to the near and medium term plans for such a base.

I. Base Scale, Layout and Location

In general, the layout of the energy bases in Shanxi, Shaanxi and Inner Mongolia will depend upon the abundance of the resources, conditions required to process such resources and direction of utilization. According to a preliminary plan, it will be divided into six energy industry regions, or energy sub-bases, each with different features. They are the Jungar coal base and the coal-to-electricity conversion base along the northern mainstream of the Huang He in Inner Mongolia, the Jingyu natural gas and chemical base and the Yushen high quality coal base in Shaanxi, the Shenfu-Dongsheng fine coal and coal-to-electricity conversion base near the border of Inner Mongolia and Shaanxi, and the coal, electricity and aluminum producing base in the northern part of the Shanxi-Shaanxi Gorge.

It is estimated that by the end of this century these energy bases will be capable of producing and delivering a fair amount of coal, electricity and natural gas. By the year 2000, they will produce more than 100 million tons of coal. Over 80 million tons will be transported out of the area by a number of railroads such as the Shuo-gang, Zhun-da, Bao-shen and Ji-tong lines. It will have a total of 8 million kW of installed power capacity. More than two-thirds of the power generated by major power plants in Dalad, Jungar, Tuoketuo and Wanjiazhai will be sent to the east. Natural gas production will exceed 3 billion cubic meters. It will primarily be transported to major cities such as Beijing, Xi'an and Yinchuan. After 20-30 years of construction, this base may become the largest supply base for energy resources and energy carriers. Every year, it will deliver several hundred million tons of high quality coal, millions of kilowatts of electricity and billions of cubic meters of natural gas. It will play a pivotal role in China.

II. Issues of Particular Concern

Besides its rich resources, the area bordering Shanxi, Shaanxi, and Inner Mongolia is also well known for its fragile ecological environment, soil erosion, severe wind storm and poor economy. As we prepare to exploit its resources in large scale, it is also necessary to have an overall plan for the scope of development and the environment. In order to improve the local economy, we need to study the policy issued by the government. If such problems are not properly dealt with, the progress of the construction of this energy base will be adversely affected.

1. Coal transportation remains an issue.

According to a national coal balance analysis for the year 2000, this border area will produce more than 100 million tons of coal. It will continue to grow by

several folds into the early part of the 21st century. Due to: 1) its excellent reserve and exploitation conditions, it requires only a small amount of investment and short work cycle that drives the cost lower; and 2) its excellent coal quality, it will become a major coal base with a large reserve and play a pivotal role in improving our social and economic environment.

2. Its water resources are relatively abundant. However, front-end work and overall planning are lacking.

To date, each coal or electric power project under construction or being planned must seek for its own water resource. In principle, the scale of the project is determined by the availability of water. For instance, the development of the Shenfu mining region uses a part of the water in Yaozheng. The plan for the Baode and Fugu Yinta power plants requires a part or the entire water resource at Tianqiaoquan. The Shenmu power plant uses the water at Hongjian Nur. As one can see, there is no long-range plan for water. Power plants and mines are looking for water locally. Either they are limited in size or they must compete for water. The first impression is that there is not enough water for a major power plant. However, surface water from the mainstream and all tributaries of the Huang He has not been systematically planned and developed.

3. Slow economic growth widens gap with the east.

A severe lack of investment capital is the root of poverty in the area. Using the six counties north of Yulin as an example, the average fixed assets investment per person in the Seventh 5-Year Plan is one-third of that of the national average. In 1990, it is 40.2 percent of that of the national average, one-fourth of that in Guangdong and one-tenth of that in Shanghai. This difference in investment causes the economic imbalance, i.e., difference in personal income and purchase power.

The average personal retail purchase in the area during the Seventh 5-Year Plan is merely 47.4 percent of that in the nation. In 1990, it was 38.3 percent of the national average, less than one-fourth of that in Guangdong and one-twelfth of that in Shanghai. By 2000, if the GNP of the area is going to reach the present national level, approximately 300 million yuan of fixed assets investment must be made every year from this point forward to keep its economy growing at a sustained and steady rate of 12.1 percent. Despite the fact that the area has all the resources required to develop an energy industry, however, it is very hard to maintain such a high rate of growth due to lack of local investment.

4. Agenda for comprehensive planning of large-scale energy resource development and environmental management has not been seen.

How to combine energy resource development with comprehensive environmental management, from planning objectives to specific treatments, has not been resolved. The area bordering Shanxi, Shaanxi, and Inner Mongolia has poor natural conditions. It is only natural that the development of coal, electric power and natural gas in the region should be separate from other regions. In addition to following national environmental protection regulations that each industry must restore the environment it disturbs, each business is also responsible for the maintenance of the environment in the area. This measure is different from the 0.5 yuan environmental management fee for every ton of coal shipped out of the area from the Shenfu-Dongsheng coal mine plan and the restoration of the open pit mine in Jungar.

III. Measures and Recommendations

1. Establish a special energy resource development region as soon as possible.

Large-scale development of energy resources in the area will soon become an important energy base in China. Moreover, this base cannot be replaced by any other forms for quite some time. Therefore, a comprehensive plan for the development of coal, electric power, natural gas, railroads, water resources, local economy, and environmental management is required. The plan should arrange the order of development and divide the effort in steps so that resources can be rationally employed and environment can be managed in an orderly fashion. Furthermore, it will ensure the construction schedule of the energy base, coordinate the distribution of profits, and promote the growth of the local economy. To this end, a special energy resource development region should be established in this area to synchronize the planning and development of energy resources, as well as water resources, transportation, environment and local economy. This special region is different compared to other "economic development regions" in place elsewhere. Its goal is to develop energy resources, guarantee our energy supply, and serve the national economy. A large conglomerate directed by a board of directors may be established on the basis of existing national corporations to: 1) coordinate the relation with others; 2) plan the overall development of all resources in the region; 3) track the market and share the information with all members; 4) decide the scale and timing of various projects such as coal, electric power, water and transportation; 5) raise construction capital and pay back interest and principal; and 6) issue and implement various measures to protect the environment in the region. In conclusion, this entity must have the highest authority (national level) to provide overall planning and organize the implementation of high level policy related to energy resource development and economic growth in the region.

2. The main approach to solving the coal transportation problem is to combine coal shipment with electricity transmission.

The basic principle of coal exploitation in the region should be to ship high-quality coal out of the region and convert low-grade coal locally. Resource exploitation and local conversion should be planned and constructed simultaneously to allow the resources to be utilized rationally. The primary product is high-quality coal to generate power. This fine coal market should focus on domestic and foreign end-users. Nevertheless, large-scale exploitation will also produce a substantial amount of low-grade coal. This resource should be converted locally. Hence, coal is shipped in the form of both coal and electricity. It is estimated that by the end of this century more than 100 million tons of coal can be produced at the base and 50-60 percent of it will be high-quality coal. By then, the total capacity of railroads such as the Jing-bao, Zhuan-Da and Shenshou-Shougang lines will be approximately 80 million tons. On this basis, the base needs an installed capacity of 10 million kW to be able to rationally utilize the resources and to alleviate the coal transportation problem.

3. To plan the water resources in and around the region ahead of time is an important way to ensure the rational development of the base on a large scale.

On the basis of the data on hand, although the water resource in the region is not very abundant, however, the sum of local and transit water resources (including surface water and ground water, regulation of surface runoff, regulation of the Huang He at Heishanxia, Wanjiashai and Longkou and water conservation measures for irrigation at the Great Bend of the Huang He) is sufficient to meet the demand in the early part of the 21st century when large-scale construction is scheduled to take place if an overall plan exists and the corresponding water projects are constructed in different stages. For example, upon completion of pivotal water projects at Heishanxia and Wanjiashai, surface water in the middle reaches of the Huang He can be regulated and purified. After water conservation measures at the Great Bend of the Huang He are implemented, if one-third of the water for irrigation can be saved, at least 3 billion cubic meters will become available. Reservoirs built on the Kuye He and Wuding He can provide 300 million cubic meters of water to meet the needs of the 3600 MW Shenmu power plant and Yulin's 2400 MW Yuhe power plant.

4. Increasing the influx of capital is a critical way to narrow the gap with the east.

In order not to expand the gap with developed regions, to rapidly change the image of poverty and backwardness, to make sure that the construction of a national energy base for coal, electric power and natural gas can proceed smoothly, and to minimize

any conflicts, we recommend that the government review and straighten out various policies regarding the distribution of economic benefits among national and local government and different departments. In particular, the region should be given top priority in terms of capital infusion. (1) Existing capital infusion and technological support programs should remain. (2) The local government should keep a portion of the tariff from products to create a local economic development fund or a bank to promote further growth in the form of loans. (3) Applications to exploit coal and natural gas ought to be reviewed rigorously. Such industries should be encouraged to face the market. The system that waives product tariff and resource tax should be repealed. (4) Railroads newly constructed in the region by the government or conglomerates must reserve at least 15 percent of their capacity for local business in order to promote its economy. (5) Keep track of the market to select leading industries in the region in order to maximize the benefits of the limited capital available. This involves using the energy industry as the "leader" to develop various compatible industries that require low investment and quick return. We should take full advantage of the limited amount of capital available from the government for the development of energy resources to build up industries such as construction materials, textile, food, metal machining, construction, transportation, commerce and cultural service. With a low level of investment, they can create a high product value, add-on value and tariff.

5. Include environmental management in the area bordering Shanxi, Shaanxi, and Inner Mongolia into the overall energy resource development plan.

The relation between each energy resource development project with environmental management and maintenance should be as follows. (1) Each business or project in the region must restore the environment it disturbs. (2) All businesses are responsible for the environment in the region. (3) A regional environment monitoring organization should be established to formulate an environmental management plan for the region and to supervise its implementation. (4) The cost of environmental management (sum of the cost to restore and manage the disturbed environment) should be included in the cost of energy. One hundred percent of this part of the fee should be used to treat the environment.

LNG Passenger Vehicle Displayed

946B0090A Beijing RENMIN RIBAO OVERSEAS
EDITION in Chinese 24 May 94 p 3

[Article by reporter Yang Lianghua [2799 5328 5478]]

[Text] A large passenger vehicle that does not burn gasoline, but uses liquefied natural gas [LNG] fuel, was

put on display at the Zhongguancun science city on 19 May and drew the interest of Chinese and foreign scientists.

The LNG vehicle fuel system researched through the cooperation of units from the Low-Temperature Center Keyang Corporation of CAS, Mianyang Gas Corporation, and Qinghua University, and installed in the large passenger vehicle which was driven for 4,000 kilometers, and demonstrated good power and economy.

Chinese scientists used a 160° Celsius low-temperature cooling device to liquefy the natural gas, reducing its mass to 1/600, put it in an insulated container and used it to fuel the vehicle. All that is needed to convert existing fuel-burning vehicles is to exchange the gas tank and fuel lines and that can be done at little cost.

In the test, this LNG vehicle consumed 38.6 liters of gas per 100 kilometers at half the cost of gasoline. A full tank of liquefied gas is good for an average of 270 kilometers. The vehicle reached speeds of 86 kilometers per hour, close to that of other fuel-burning vehicles. Hydrocarbon and carbon monoxide emissions were respectively one-fifth and one-twelfth that of other fuels showing the important significance it could have for environmental protection.

Increase Noted in First Quarter Power Production

946B0090B Beijing RENMIN RIBAO OVERSEAS
EDITION in Chinese 10 May 94 p 1

[Article by reporter Gao Xinghua [7559 5281 5478]]

[Text] Beijing, 9 May (XINHUA)—China produced 210.9 billion kWh of electric power in the first quarter of 1994, 10 percent more than the previous year, and about 24 percent of the calculated target for the whole year.

According to figures from the Bureau of Electric Power, thermal power accounted for 183.4 billion kWh of the total power generated, 7 percent over the same period last year and hydropower was 27.5 billion kWh, 20 percent higher than last year.

Up to the end of last year, China's installed power capacity was up to 180,000MW, and the newly installed capacity for this year is expected to be 12,000MW. The power output target for the full year is 890 billion kWh.

It is estimated that in the second quarter, China's power output will also increase by about 10 percent, on par with the first quarter, but there is not much change in the outlook for the power shortage ratio.

Huang Yicheng on China's Energy Development Strategy

946B0094A Beijing JINGJI RIBAO [ECONOMIC
DAILY] in Chinese 15 May 94 p 2

[Article by Huang Yicheng, Vice Chairman of the Financial and Economic Committee and Deputy Head of the Leading Group for Nuclear Power Plants]

[Text] Energy is the indispensable material basis for the advancement of human society, its economic development and daily livelihood. Based on Comrade Deng's idea of "three steps," China wants to bring its economic level up close to that of advanced countries, and whatever other conditions that may entail, a guaranteed supply of energy is an absolute necessity. Therefore, an energy development strategy that comports with Chinese realities has to be thoroughly worked out.

China's particular realities are, one, a large population, and two, a low level of energy consumption. In developed countries, the average consumption of energy per person per year is over 5 tons of standard coal (in the U.S. it is over 10 tons), and China's total consumption in 1992 was 1.1 billion tons of standard coal, which when divided into the population, comes out to 1 ton of standard coal per person. And, the third reality is that coal makes up about three-fourths of the total energy consumed.

The economy will develop and the people's livelihood will improve, and surely the average consumption of energy will increase, but that increase will be restricted by many factors, such as, energy resources and the environment. In another 50 or 60 years when China's economy will be approaching the level of advanced world nations, the population will have increased to about 1.5 billion, and the average annual per capita consumption of energy will be up to, say 3 tons, if not 5 tons, of standard coal, which will put the total national energy consumption figure at 4.5 billion tons. At the present consumption level of 1.1 billion tons per year, the volume of oxides of sulfur and nitrogen, and carbon dioxide pollutants that China discharges into the atmosphere is already very close to that of the U.S., which is the highest in the world. It's hard to imagine what peril to the national economy and atmospheric environment awaits after decades more of producing, shipping and burning up several billions of tons of coal per year.

We are living in an interdependent world, and China's energy development strategy and policy will transcend national borders, not only affecting the existence and development of people here, but throughout the whole world. Therefore, while doing research on an energy development strategy for China, it will be necessary to seek a balance among the needs, resources, financial strength, and other conditions, as well as to maintain a balance among the production and consumption of energy resources and the ecological environment.

Based on the above principles, it appears that China's energy development strategy, besides wanting to speed up the development of conventional energy resources, and through adopting major measures, raise the energy utility ratio; and, as well as finding ways to make better use of the 1.1 billion tons of standard coal being consumed now, must also give consideration to the energy needs of 800 million peasants and develop hydropower, bio-energy, wind power, solar energy, and methane. The proposal by the leadership of the State Council that for

the next few years cattle in agricultural areas be raised on straw has evidently been successful, notably in that it has helped to further the development of rural economies.

China will be producing 600 to 700 million tons of straw per year, and if that resource is fully utilized it could write a new chapter, and a good one. The value of straw as a resource has not yet been fully appreciated even after several thousand years, having been used mainly as fuel or recycled into the fields as fertilizer. To use straw now to develop the stock raising industry in agricultural areas is definitely a pioneering exploit.

One can envision raising cattle, sheep and pigs on the vitamins and protein (after ammoniation) from straw, and then using the manure as the raw material for producing methane. Methane is a clean energy resource that can be used to relieve the rural energy shortage. Only the carbon and hydrogen contained in straw is needed to make methane, and the remaining residues contain nitrogen, phosphorus and potassium, and experience has shown that they are very good fertilizers. Using straw in this way will develop the livestock industry, supply rural energy, and increase the use of organic fertilizers. It has great economic value, and can improve the rural ecological environment.

China is ahead of the world in the production of methane, but it is little used in rural economy, because small household ponds are inefficient producers of methane; the process is laborious and it takes a long time to develop. The foreign experience has been that building large methane ponds on cattle (and other livestock) farms and using heating and mixing technology can triple again the output of methane, and it can be produced all year long. Using that method on Chinese farms can produce the energy needed for cooking and any excess can be used for electric power.

To sum it up, "straw engineering" could be a big boost to rural economic development. It has been suggested (the State Planning Commission and Ministry of Agriculture) that state funds be issued to China's developed livestock raising areas (such as Zhoukou in Henan) for building test plots in those areas by gathering together stock-raising farms to build large pools, and using heating and mixing technology, mechanizing the handling of materials, and in short, industrializing the process, and then using the methane to supply energy for cooking and electric power.

The development of new methane pools is not only a good way get energy for rural areas as well, but a way to suit measures to local conditions in urban and village areas. It could also be a good energy-conservation method for processing solid wastes and trash throughout the society. Some enterprises that produce residues and liquid wastes from their operations could build new kinds of high-efficiency methane pools by which they could get energy and manage the environment.

Bio-energy is another way to use agricultural products to produce alcohol, and this is being tested in several countries. There are also good prospects for using sawdust, sugar cane residues, fruits and vegetables to produce alcohol for vehicular fuels.

**Energy Projects Top List of Planning
Commission's Priority Construction Items**

946B0096A Kunming YUNNAN RIBAO
in Chinese 30 Apr 94 p 2

[Article by reporter Li Anding [2621 1344 1353]]

[Text] Beijing, 29 Apr (XINHUA)—The State Planning Commission has just released its list of key construction projects for 1994.

In the notification concerning the 1994 list of key construction projects, the State Planning Commission urged every department and locality to strongly support these projects, and to help resolve problems that might arise in connection with construction. State banks and pertinent commercial banks and the various departments and localities must, in accordance with the State plan, get the construction funds and the overall funding secured and in place in good time.

Auditing departments must increase their vigilance for any department or unit that might be improperly retaining or misappropriating funds for national key construction projects. The enterprises and units involved must give priority to the ordering of facilities and materials for key national construction projects, and honor their contracts (including product prices, specifications, quality, and delivery schedules). The various levels of local governments will see that the land acquisition and clearing work for key national projects gets done.

Included in the 1994 key national projects are:

- Coal projects (22 items): Kailuan Mining District in Hebei; Datong, Gujiao, Yangquan, Luan, and Jincheng Mining Districts in Shanxi; Jungar stage one in Inner Mongolia, the Yuanbao Shan open-pit mine at Pingzhuang Mining District and Liaoning Tiefsa Mining District; Shuangya Shan and Qitai He Mining Districts in Heilongjiang; Huanian and Huaibei Mining Districts in Anhui; Yanzhou and Zaozeng Mining Districts in Shandong; Pingdingshan and Yongxia Mining Districts in Henan; Xiaolongtan open-pit coal mine, Yunnan; Shenfu, Dongsheng Mining District of the Huaneng Refined Coal Corporation; Huangling Mining District, Shaanxi; Lingwu Mining District, Ningxia; Chaohua mine shaft, Zhengzhou; and the Gaocheng mine.
- Petroleum projects (6 items): Daqing oil field development, Heilongjiang; Liaohe oil field development, Liaoning; Shengli oil field development, Shandong;

Tarim area development, Xinjiang; Xinjiang oil field development; and Nanhai Western Petroleum Corporation, Guangdong.

- Electric power projects (39 items): Ji Xian power plant, Tianjin; Tieling power plant, Liaoning; Shuangliao power plant, Jilin; No. 3 power plant 2nd phase, Harbin; Guangzhou pumped-storage station, 1st phase; Changshu power plant, Jiangsu; Beilungang power plant, Zhejiang; Shisanling pumped-storage power station, Beijing; Shuikou hydropower station, Fujian; Geheyan hydropower station, Hubei; Wuqiangxi hydropower station, Hunan; Daguangba hydropower station, Hainan; Yantan hydropower station, Guangxi; Tianshengqiao high and low dam projects, Tongjiezhi, Baozhusi, and Ertan hydropower stations in Sichuan; Dongfeng hydropower station, Guizhou; Manwan hydropower station, Yunnan; Yamzho Yumco pumped-storage station, Xizang; Lijiaxia hydropower station, Qinghai; Suizhong power plant, Liaoning; Yuanbaoshan power plant 3rd phase, Inner Mongolia; Xibaipo power plant, Hebei; Dalad power plant, Inner Mongolia; Ma'anshan No. 2 power plant, Anhui; Jiaying power plant, Zhejiang; Yanshi power plant 2nd phase, Henan; Hegang power plant, Heilongjiang; Yimin 1st phase, Inner Mongolia; Waigaoqiao power plant, Shanghai; Weihe power plant 2nd phase project, Shaanxi; Jingyuan power plant 2nd phase, Gansu; Zou Xian power plant 3rd phase, Shandong; Shimen power plant, Hunan; Hengshui power plant, Hebei; Yangquan No. 2 power plant, Shanxi; and the Tianhuangping pumped-storage station, Zhejiang.

Hydropower

Geheyan's 300MW No 3 Unit Operational

94P60294 Beijing RENMIN RIBAO OVERSEAS
EDITION in Chinese 7 Jun 94 p 1

[Text] XINHUA SHE, Wuhan, 4 June—Today, following a 72-hour trial run, the 300MW No. 3 generator of the Geheyan hydroelectric power station officially began operations. Geheyan, located on the Qing Jiang, is a major State construction project. Work was completed on the No. 3 unit 6 months, 27 days ahead of the State's schedule. The Geheyan power station is a major peak regulatory station in the central China power grid, one of the nation's four big grids, and will have four 300,000-kilowatt generators for a total installed capacity of 1200 megawatts.

1994 Plan To Put Large, Medium Units On Stream

94P60306A Beijing SHUILI FADIAN [WATER POWER] in Chinese No 5, 12 May 94 p 11

[Text]

1994 Plan To Put Large, Medium Units On Stream (Unit: 10,000 kilowatts)					
Total	1st quarter	2nd quarter	3rd quarter	4th quarter	Attempt will be made to make these units operational:
	Daguangba No. 1 6	Geheyan No. 3 30	Manwan No. 4 25	Geheyan No. 4 30	Wuqiangxi No. 1 24
	Qingxi No. 3 3.6	Dongfeng No. 3 17	Shuikou No. 3 20	Manwan No. 3 25	Dongfeng No. 2 17
	Shuikou No. 2 20	Daguangba No. 2 6	Tongjiezi No. 4 15	Shuikou No. 4 20	Yantan No. 4 30.25
	Guangxu No. 4 30	Yantan No. 3 30.25	Qingxi No. 4 3.6	Taipingyi No. 1 6.5 Daguangba No. 3 6	
293.95/17 units	59.6/4 units	83.25/4 units	63.6/4 units	87.5/5 units	71.25/3 units

Note: Tianshengqiao Second Cascade's No. 3 and No. 4 units (440 MW) are among those units for which an attempt will be made to go on stream in 1994.

(Supplied by Hydroelectric Rural Electrification Department, Ministry of Power Industry)

Yamzho Yumco Could Be Finished a Year Early

94P60317 Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 21 Jun 94 p 1

[Text] The Yamzho Yumco pumped-storage hydroelectric power station project, in which the State will invest a total of 1.358 billion yuan, is the largest and most expensive hydropower project in Xizang since Liberation. It is also the highest (above sea level) large-scale hydropower station in the world. As of the end of May, more than 800 million yuan had been invested and more than 75 percent of the civil engineering work had been completed. It is estimated that the entire project could be finished a year early, coming on stream around the end of 1995.

Dam Site Selected for Huge Xiluodu Station

946B0096B Kunming YUNNAN RIBAO in Chinese 8 May 94 p 1

[Article by Wang Daihong [3769 0108 1347]]

[Text] After having sent over 80 experts, academicians, and engineers to Xiluodu on the border between Yongshan County, Yunnan, and Leibo County, Sichuan, to make investigations, the Ministry of Electric Power has just now settled on the dam site for the huge Xiluodu hydropower station.

Xiluodu will be a huge hydropower station on the Jinsha Jiang. The many experts who made the investigations deemed it to be a site unmatched in the world for building a dam, and the loss of arable land and the population resettlement will be the smallest in China for a dam of its size. For the near term, the installed capacity of the station will be 12,000MW, and with a guaranteed power output of 4,017MW, its annual output will be

57.31 billion kWh. The long-range installed capacity will be 15,000MW, guaranteeing an output of about 6,300MW for an annual output of 65.5 billion kWh. The experts unanimously agree that Xiluodu has the best geological and hydrological conditions in China for building a hydropower station, and besides providing electric power it will be useful for flood prevention, sand retention, logging, and down-river navigation. The Chengdu Survey and Design Academy intends to have the feasibility study for the project completed in 1995.

Thermal Power

World Bank Loan for Yangzhou Thermal Power Project

40100074C Beijing CHINA DAILY in English 30 May 94 p 1

[Article by Wang Yong: "State Receives Loan for New Power Plant"]

[Text] China yesterday signed a \$120 million financing package under a special World Bank programme for a large domestic power project.

The financing consists of two segments: a \$90 million syndicated loan and one for the equivalent of \$30 million in yen.

The first portion is arranged by Bank of Tokyo International (HK), Dresdner (Southeast Asia) and J.P. Morgan.

The financing carries a 15 year maturity and a five year grace period. All principal repayments after the 10th year are fully guaranteed by the World Bank.

A total of 12 banks representing six nationalities have participated in the financing.

The yen loan, arranged by Nippon Life Insurance Company of Japan, carries a 15-year maturity. Four Japanese life companies support the financing.

The agreement is China's first under the World Bank's Expanded Co-financing Operations Programme (ECO).

The provisions allow China, represented by the Ministry of Finance, to borrow with the World Bank acting as guarantor.

It will be the ministry's first syndicated loan financing in the international market.

The \$120 million will provide partial funding for the Yangzhou Thermal Power Project in eastern China's Jiangsu Province, which will cost \$1.3 billion.

As one of China's largest energy projects to date, the thermal power plant involves construction of two 600-megawatt coal-fired generating units and ancillary facilities near Yangzhou City.

The remaining funding for the project will come from the State Energy Investment Corporation, Jiangsu Provincial Investment Company, Yangzhou Municipality, Jiangsu Provincial Electrical Power Company and the World Bank.

In a meeting with financiers at the Great Hall of the People, Premier Li Peng extended his congratulations regarding the agreement.

"China will continue to import foreign capital and equipment to bolster the power industry for a long time to come," he said.

Although the industry has made significant progress for many years, it still cannot keep pace with the nation's economic growth, he said.

"So we've planned an average annual growth rate of 8-9 percent for the industry over the next five years," he said.

This momentum will create a huge domestic market for foreign power businesses.

Li expressed hope that China and the World Bank, which have many years of successful cooperation, will cooperate further to finance basic industries and infrastructure.

He said China has the ability to repay foreign loans as its economy and financial reforms succeed.

Raytheon Unit Will Be Partner in Hubei Power Plant Project

40100076B Beijing CHINA DAILY (Investment & Trade) in English 6 Jun 94 p 2

[Text] A unit of Raytheon Co. will be a partner in a \$52 million contract to provide services and equipment for

two coal-fired power plants in China. Raytheon-Ebasco Overseas Ltd, and Foster-Wheeler Energy Corp of New Jersey shared the contract with China National Technical Import and Export Corp in Beijing. The two 300-megawatt, coal-fired power plants in China are located in Hubei Province. (BW-Agencies)

Feasibility Study on Hongyanchi No. 2 Power Plant Passes Inspection

94P60295 Urumqi XINJIANG RIBAO
In Chinese 1 Jun 94 p 1

[Text] On 27 May, the feasibility study on the first stage of the Hongyanchi No. 2 power plant, a major State construction project, passed examination in Urumqi. Based on the Autonomous Region's ever-increasing demand on the electric power load and on environmental protection requirements, this stage of the plant calls for four 200-megawatt units. Construction would begin in 1997 and be completed in the year 2000. The National Energy Investment Corporation and the Autonomous Region have struck a 60-40 joint investment agreement. According to experts, when completed, this project will not only meet the increasing load demands of the grid but will also supply heat for the city, replacing the heat now supplied by dispersed small boilers.

Work Progressing Smoothly on Guang'an, One of Nation's Largest Power Plants

94P60322 Chengdu SICHUAN RIBAO
in Chinese 12 Jun 94 p 1

[Summary] With a total installed capacity of 2400MW, the Guang'an power plant will be one of the largest in the nation. The project is divided into three phases. The first phase calls for the installation of two 300MW generators and construction will cost 2.9 billion yuan. The necessary funding will come from the National Energy Investment Corporation (60 percent) and from the Provincial and local governments (40 percent). In October 1993, the Guang'an Power Plant Preparatory Group was created in Guang'an [in western Sichuan Province]. The project site will cover some 1,800 mu and is located 1.2 kilometers north of Daishizhen in Guang'an County. The site is 10 kilometers from the Xiangyu Railroad's Guang'an station and 20 kilometers from the county seat. The development of the coal resources needed by the plant is now being speeded up and a 1.95-million-ton shaft is about to be opened. Early this year the Chengdu Railway Bureau dispatched personnel to Huaying and Linshui to conduct surveys and to plan the construction of a railroad that will bring the coal to the plant in a timely fashion. The project involves enormous investment and as of now four or five foreign investors have shown strong interest in joint ventures.

Maoming's Oil Shale Power Plant is Nation's First*946B0090C Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 16 May 94 p 2*

[Article by Cai Zhan [5591 3277]]

[Text] The curtain has been raised for China's first oil-shale power plant which will be built at the southern oil city of Maoming. Maoming is rich in oil-shale resources. Maoming's oil-shale power plant, located in the open-pit mining district at Maoming, is equipped with two 50MW generators for a total installed capacity of 100MW. The key technology for the plant, the circulating fluidized-bed and boilers, were imported from Finland. The turbines and generators were built entirely in country. The early-stage preparations for the project have been laid out and the detailed survey for the site has been completed. This project is expected to be completed by the end of 1996 and to begin generating power under normal operations in March 1997.

Coal**Exploration Adds to Guizhou Reserves***94P60272 Guiyang GUIZHOU RIBAO in Chinese 13 May 94 p 1*

[Text] After an eight-year effort, the 159th Team of the Guizhou Coal Field Geology Bureau has verified geologic reserves in the Mayi West fields of 1.72377 billion tons. In Panxian recently, the State Planning Commission and the Ministry of Coal Industry examined the "Geological Appraisal of the Mayi West Exploration Zone" which confirmed these geological reserves.

The Panjiang Special Zone has already verified coal geologic reserves of some 9.2 billion tons, including 4.11718 billion tons in three fields: Pannan, Mayi East, and Mayi West. These three fields cover an area of 265 square kilometers (with an average of 15.71 million tons per square kilometer). The quality of the coal would make it useful for motive power or in the chemical industry. The Mayi West coal field will boost the effort of the Panjiang Mining Bureau to plan and construct 10-million-ton mines in the period of the the Ninth 5-Year Plan.

National Plan for Developing Clean Coal May Be Adopted in '94*40100064A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 9 May 94 p 8*

[Article by Chang Weimin: "Search for Clean Coal Picks Up"]

[Excerpts] A national plan for developing clean coal is expected to be adopted this year, creating more business opportunities for foreign companies.

The plan, to be drawn up by the State Planning Commission, the State Science and Technology Commission and the State Economic and Trade Commission, is a response to the outcry being raised at home and abroad to protect the environment.

China, where coal constitutes 76 percent of energy consumption, should accelerate the development of clean fuels, say officials from the Ministry of Coal Industry.

The State Council, China's cabinet, has authorized the three commissions to formulate a plan to beef up the development efforts, experts say.

Discussions on the plan are now underway, BUSINESS WEEKLY has learned.

China has developed clean coal and promoted its application for several years, but officials and experts admit they face funding shortages.

In the meantime, more foreign companies, which have been seeking opportunities in China for developing clean coal, are calling for a policy guideline.

In an interview, Zhu Deren, vice-president of the Central Coal Mining Research Institute, said quick development of clean coal can be reached with State support.

The development requires collaboration nationwide and co-operation with the outside world. The plan will endorse such interchange, Zhu said.

The Central Coal Mining Research Institute, which oversees 17 research institutes that employ 80,000 scientists and technicians, recently set up a clean-coal engineering and technology centre.

The centre, approved by the Ministry of Coal Industry, is expected to be developed into a national base for research and development. [passage omitted]

Zhu pointed out that the development and application of clean coal in China are not the same as in the West, where conditions are different.

In China, only 30 percent of coal consumption is for generating electricity, compared with 87 percent in the United States. The bulk of raw coal is burned for heating and cooking.

This presents a much more difficult task for the country in raising coal-burning efficiency and reducing pollution, Zhu said.

Surveys show that 6 billion cubic metres of waste gas containing coal powder and methane is pumped out of coal mines and into the air every year. Another 3 million tons of coal powder is emitted into the air each year by transportation vehicles.

China produced 1.14 billion tons of coal last year but only 19 percent was washed or classified, compared with nearly 100 percent in Western nations.

Zhu believes the development of clean coal will receive stronger support not only from the central government but from the outside world. [passage omitted]

Stage Set for Big Shaanxi Project

40100074B Beijing CHINA DAILY (BUSINESS WEEKLY) in English 30 May 94 p 7

[Text] Preparations for the 40 billion yuan (\$4.6 billion) Shenfu-Huanghua Project to exploit and ship coal in North China are drawing to a close, and full-scale construction is expected to start soon.

The ambitious project calls for expanding the Shenfu-Dongsheng Coalfield, in Northwest China's Shaanxi Province, so it can produce more than 100 million tons a year. The project also calls for building the 820-kilometre Shenfu-Huanghua Railway and the Huanghua Port on the Bohai Sea, which will be able to handle up to 100 million tons of coal a year.

The project is designed to transport high-quality coal from the Shenfu-Dongsheng Coalfield to the eastern part of the country.

The Shenfu-Dongsheng Coalfield now has production capacity of 10 million tons. Its second-stage development would expand annual capacity to 30 million tons, and is among the 151 major national projects for 1994.

The Shenfu-Shuoxian section of the Shenfu-Huanghua Railway is already operating. The design of the electrified, multiple-track Shuoxian-Huanghua Railway has been completed, thanks to the efforts of more than 300 designers over the past several months.

A 1,000-member survey team is making the final survey along the railway line to pave the way for construction.

Work on the overall design of the Huanghua Port is now in full swing. Preparations will soon be completed for building supplementary projects such as power and water supplies and telecommunications and communications networks.

Slurry Technology Moves Ahead to Replace Oil

40100075A Beijing CHINA DAILY (Science) in English 3 Jun 94 p 5

[Excerpts] China has caught up with the world's developed countries in the technology and industrial application of slurry, a new coal-based clean fuel.

Hao Fengyin, chairman of the National Research Centre of Slurry Engineering and Technology, said although China has been late in researching this field, it has developed its own set of technologies.

Slurry—composed of 60-70 percent coal, 30-40 percent water and 1 percent of additives to keep the mixture stable and fluid—is believed to be a good substitute for fuel oil. [passage omitted]

The Chinese showed interest in exploiting and using slurry to supplant oil and listed it as one of the key projects in the three consecutive "Five-Year Plans" starting from 1980.

From 1985-90, China succeeded in research of slurry, developed a complete set of technologies and built demonstration projects and bases for experimenting with slurry preparation, pipeline transportation and industry-oriented combustion.

Since 1990, the State has approved five energy-saving and environmentally sound projects using slurry instead of oil, bringing to a new stage the large-scale, streamlined industrial application of slurry technology.

At present, six slurry preparation plants have been built, with their annual production capacity totalling 1 million tons. Specialized workshops can produce 500 to 2,000 tons of slurry additives, with only two-thirds, or even half, the cost of their foreign equivalents.

Breakthroughs were also made in slurry combustion for industrial scale boilers and kilns and power plant boilers, slurry storage and transportation and research and development of specific equipment.

Hao said China is developing second-generation slurry technology, including preparation of super-low ash slurry and intensified low-sulphur combustion, which has attracted the attention of foreign counterparts.

It is estimated that by the end of this century, China's slurry production will replace 10 million tons of fuel oil and the capacity of pipeline transport will reach 30 million tons.

Hao said this will help ease the congestion of rail transportation and reduce emissions of ash and other pollutants into the atmosphere. [passage omitted]

"It is imperative to put the slurry technology into full play, so as to attract more clients, domestic and foreign," he added.

He proposed to set up a hi-tech coal processing conglomerate based on the national research centre to undertake large-sized projects in and outside China.

He also expressed China's willingness to develop international co-operation, from the pure technological type to an all-around one incorporating technology, industry and trade.

This would pave the way for China's slurry technology and products to enter world markets, he added.

Construction Begins on Fluidized-Bed Power Plant

94P60293 Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 13 Jun 94 p 1

[Summary] Construction recently began on China's first 15-megawatt pressurized fluidized-bed combustion combined-cycle experimental power facility located at the Jiawang Power Plant in Xuzhou, Jiangsu Province. The plant is a major key technology project under the State's 8th 5-Year Plan. Equipment installation should begin in the third quarter of 1994. This high-technology breakthrough project for clean coal burning is being followed closely by domestic and foreign energy circles and involves some two dozen units including the State Planning Commission, the Jiangsu Electric Power Bureau, and Southwestern University. The pressurized fluidized-bed combustion combined-cycle power plant is characterized by high combustion efficiency, good comprehensive utilization and low environmental pollution. Construction preparations began at the end of 1992 when the preliminary plans for the plant passed State examination. In November 1993 plans were again reviewed, this time by an expert team under the State Planning Commission. The project should be fully operational by the end of 1995.

Oil and Gas

Big South China Sea Field To Begin Operations in Summer '94

40100050A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 4 Apr 94 p 6

[Article by Zheng Caixiong]

[Text] Guangzhou—Oil production in the east district of the South China Sea will be augmented this summer when a new offshore oilfield goes into operation.

A pipeline to the Xijiang 24-3 oilfield was installed late last month, and production is scheduled to start in August.

Construction on the oilfield began a year ago. When completed it will have the capacity to pump 1.58 million cubic metres of oil annually.

Xijiang 24-3 will become the fourth offshore oilfield operating in the east district of the South China Sea.

The oilfield is being jointly developed by Phillips Petroleum International Asia, Pecten Orient Co of the United States and China Offshore Oil Nan Hai East Corp (CONHE), a subsidiary of China National Offshore Oil Corp.

CONHE accounts for 51 percent of the more than \$600 million being invested in Xijiang 24-3.

Another Xijiang oilfield being developed by CONHE, Phillips and Pecten, Xijiang 30-2, is expected to begin production next year.

The east district's three existing oilfields—Huizhou 21-1, Huizhou 26-1 and Lufeng 13-1—had pumped 638,000 tons of oil by March 13.

Last year CONHE pumped 2.94 million tons of oil, more than 50 percent of the country's offshore output.

CONHE, China's major oil exploration company in the South China Sea, is expecting more foreign investors to explore and develop the east district, which is believed to contain large deposits of oil.

From 1983 to 1993, more than 30 foreign oil companies—including Shell, Amoco, BP Petroleum, Ampolex, Occidental, Japex and Getty—invested \$1.37 billion in exploring and developing the area.

Huizhou 21-1 started production in 1989 and Huizhou 26-1 in November 1991. They were jointly developed by CONHE and ACTOG, which consists of Agip (Overseas) Ltd of Italy, Chevron Overseas Petroleum Ltd and Texaco Petroleum Maatschappij (Nederland) BV.

Lufeng 13-1, which started production last October, was jointly developed by CONHE and the Japanese JHN oil group, which consists of Japan Petroleum Exploration Co, Huanan Oil Development Co and Nippon Mining Co.

JHN put up 75 percent of the \$300 million it cost to develop the oilfield while CONHE provided the balance.

By 1997, eight new oilfields, including Huizhou 32-2, Huizhou 32-3 and Liuhua 11-1, will be pumping up to 8 million tons of crude oil. The cost of building them will exceed \$2.5 billion.

New Competitive Bidding Policy Cracks Rigid Central Planning

40100066B Beijing CHINA DAILY (ECONOMICS) in English 18 May 94 p 2

[Article by Chang Weimin: "Oil Drilling Open to Bidding"]

[Text] The oil exploration sector has cracked decades of rigid central planning by opening up regional drilling to a competitive, national bidding process. The China National Petroleum Corporation (CNPC) yesterday said 24 blocks of land totalling 294,000 square kilometres were set aside for oil exploration. Through three rounds of bidding nationwide, nine oilfields and a CNPC subsidiary have been awarded 15 blocks totalling 150,000 square kilometres scattered in eight provinces and autonomous regions. Economists spoke highly of the bidding, saying competition benefits the efforts to reform in line with the market economy.

Chinese oilfield companies previously were only allowed to explore in their home province or region. Now, any company can submit a bid to drill for oil in any part of the nation. The winning fields include Daqing in Heilongjiang Province, Shengli in Shandong, Liaohe in Liaoning and Xinjiang in Xinjiang Uygur Autonomous

Region. CNPC expects big results from these new explorations. In the third round alone, six oilfields were awarded seven blocks which contain about 664 million tons of crude oil and 172 billion cubic metres of natural gas. Contracts for exploring the seven blocks, located in Heilongjiang, Shandong and Henan provinces and Inner Mongolia and Xinjiang autonomous regions, were signed early this month. Within three to five years, the six oilfields will conduct seismic work, analyzing reserves and drilling test wells in contract blocks. Total investment for exploring the seven blocks is estimated at 450 million yuan (\$52 million).

CNPC, which oversees the country's onshore oil exploration and development, conducted two similar rounds of bidding last year. Five oilfields and a CNPC subsidiary won eight blocks totalling 94,000 square kilometres, with an investment of 1.6 billion yuan (\$184 million) to drill land in Xinjiang, Gansu and Inner Mongolia. CNPC said work has begun in those eight areas as scheduled.

In Xinjiang's Santanghu Basin, industrial flows of crude oil have been obtained. CNPC says breaking the cycle of isolating oil drilling solely to the local oilfield will speed up exploration and development in promising areas.

China, which annually produces 142 million tons of crude oil, needs more energy for a 9 percent economic growth in the next seven years. Top oil officials expect more reforms in the industry to come soon. An official from the Ministry of Geology and Mineral Resources said its enterprises will take part in upstream as well as downstream oil operations with approval from the State Council. The ministry used to look for resources only and hand over its exploration results to national oil firms without returns. That means the ministry would become national oil firms' partner in some areas.

40,000 Square Kilometers of Offshore Blocks Open to Foreign Oil Companies

946B0090D Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 19 May 94 p 1

[Article by reporter Gao Xinghua [7559 5281 5478]]

[Text] Beijing, 18 May (XINHUA)—The China Offshore Petroleum Corporation will open up new blocks to foreign oil corporations for commercial activity.

This is the first call for commercial activity following the four periods of open bidding for operations in China's coastal waters. There are 13 blocks available in the basins at Yinggehai, southeast Qionghai, and the mouth of the Zhu Jiang, a total area of 40,000 square kilometres.

A China Offshore Petroleum Corporation geologist, Gong Zaisheng, told reporters that this offer is being made to expand oil and natural gas prospecting and development in the near-ocean areas. Among the new

blocks to be offered, those in the Yinggehai and southeast Qionghai basins have very good prospects for natural gas. They were originally being retained for local operations, but because of insufficient funds and technology, part of those areas have been opened up to foreign commercial interests. There is good potential for exploration particularly because of the high temperatures and pressures in the deep strata of those areas.

The China Offshore Petroleum Corporation has sent letters to 80 oil corporations announcing the offers, and they have generated considerable interest.

New Flexibility Will Smooth Foreign Cooperation

40100074A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 30 May 94 p 1

[Article by Chang Weimin: "Oiling the Wheels"]

[Text] China will employ more flexible policies to open up new horizons for foreign investment in its oil industry.

Wang Tao, president of the China National Petroleum Corp. (CNPC), said co-operation with foreign governments and companies, unfurling offshore as well as onshore, will take more flexible forms.

In an interview with BUSINESS WEEKLY, Wang said a wide range of joint ventures is to be forged to tap the country's petroleum resources.

Wang revealed that Chinese and international oil firms are working on possible joint ventures in upstream as well as downstream operations.

Big projects can be expected to begin immediately once approved by the government.

China's oil industry, which annually produces 144 million tons of oil and 16 billion cubic metres of natural gas, has absorbed \$15 billion in overseas investment over the past 15 years.

Wang is leading a 54-member Chinese delegation to the 14th World Petroleum Congress opening today in Stavanger, Norway.

Wang said the oil delegation, the largest the country has ever sent abroad, will promote Chinese views and ideas on overcoming global challenges in energy development.

China, which is to host the 15th World Petroleum Congress in Beijing in 1997, expects important information to emerge in Stavanger.

The Chinese delegates are to cultivate foreign countries' views on energy development and discover new measures for protecting the environment.

"We hope exchanges on a wide range of topics in Norway will help pave the way for greater foreign co-operation," Wang said.

He praised China's oil development over the past 15 years, saying foreign co-operation has helped raise operations to a new stage.

Chief among the accomplishments are that:

- About one-fifth of the country's land has been opened to foreign oil exploration and development.

Foreign co-operation started 15 years ago in the country's offshore areas, and was extended onshore last year with the opening of international bidding for exploration in the Tarim desert basin in Xinjiang Uygur Autonomous Region.

Wang said exploration contracts with foreign firms are being carried out.

Encouraged by China's open policies, foreign firms are not only exploring virgin territory but are also enhancing the recovery of oil in existing oilfields.

More than 70 foreign oil firms from 15 countries have applied for another round of bidding for onshore operations. Results of the bidding are due within three months.

The foreign firms expect to explore 26 blocks and start 11 enhanced-recovery projects.

- Co-operative projects in oil refining and petrochemical manufacturing are expected to satisfy the rising demand in China, which anticipates 9 percent economic growth in the next seven years.
- Foreign companies will also work with Chinese on engineering, technical research and equipment manufacturing.

Last year, CNPC signed \$206 million worth of contracts for engineering and labour services abroad. The volume equalled the total for all of the 1980s.

- Preparations for overseas oil operations and financing are underway.

Advanced Technology, Reform Breathe New Life Into Karamay

40100079A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 20 Jun 94 p 6

[Text] Urumqi (Xinhua)—Reports of the demise of Karamay, China's oldest oilfield, seem to have been greatly exaggerated.

In the past 12 years, the discovery of new deposits and development of new extraction techniques has given what looked to be a declining field in the 1970s a new lease on life.

For the past several years, its crude oil output has increased 300,000 tons annually.

Last year, it produced 7.6 million tons of crude oil. And for the past four years its output has been the fourth largest in China.

Karamay Oilfield was established in the deserted northwest part of the Junggar Basin in Northwest China's Xinjiang Uygur Autonomous Region. Its first well started yielding crude oil on October 29, 1955, and five years later had an annual output of 1.6 million tons.

But by the mid-1970s the oil output started to drop and no new deposits were found. Many thought the oilfield was dry and the people of Karamay became worried about their future.

When the Chinese central government began to adopt the policy of reform and opening to the world in 1979, workers at the Karamay Oilfield were greatly encouraged. They launched a drive to re-survey the old area and export new parts.

Karamay is rich in heavy oil. Since the oil seam is close to the surface, the light elements and gases of the oil had seeped out of the strata long ago. So the oil appears as asphalt and is difficult to extract.

But with advanced foreign and domestic technology, technical personnel at Karamay succeeded in extracting the oil by injecting vapour into the layer below ground. As a result, the field's output of heavy oil increased greatly and reached 1.5 million tons annually for three years.

The technicians also used the latest technology to re-analyze old sections, discovering three layers of oil deposits in the strata above and below the old oil-bearing stratum, thus paving the way for increasing the oil output.

They also discovered and opened up several new areas, including the Fengchen, Xiazejie, Dongpaizi, Maozhuang and Huoshaoshan oilfields. The output of these new fields has surpassed 1 million tons a year.

As its oil output has increased, Karamay has also developed oil-processing industries. It is able to refine 5.45 million tons of crude oil per year and produce more than 190 oil products, 39 of which meet international standards. More than 20 are exported to Japan, the Democratic People's Republic of Korea and countries and regions in Southeast Asia.

A plant to produce 140,000 tons of ethylene annually is being built and due to be completed next year. Experts said the project will help bring Karamay back to its former glory as an oil-rich centre.

Nuclear Power

Recent Accomplishments of the Nuclear Power Programme in China

40100080A Tokyo THE FIFTH INTERNATIONAL CONFERENCE FOR NUCLEAR COOPERATION IN ASIA in English Mar 94 pp 1-10

[Speech by Chen Zhaobo, vice chairman/vice minister, China Atomic Energy Authority (CAEA), executive vice president, China National Nuclear Corporation (CNNC)]

[Excerpt] [Passage omitted]

1. Status of Nuclear Power Construction

The Qinshan NPP [Nuclear Power Plant] the first NPP comprising 300 MW PWR, was designed and constructed and is now being operated by self-reliance. It was connected to the power grid on December 15, 1991. It reached full load in July 1992, load factor was attained as high as 66 percent in 1993. Justifying a high attainment, Qinshan NPP has gain much to our satisfaction. As a prototype reactor, it is characterized by its good design, fabrication, and construction as well as qualified personnel and good management. Therefore, we have every reason to confide in a constant, reliable, and safety operation on domestic NPP. Apart from some components imported such as pressure vessel, almost all the equipment for Qinshan NPP come from the domestic market. And at the present stage, we're trying our best to have these components made in China.

Guangdong's Daya Bay NPP with its two 900 MW PWRs is a project of co-operation with Framatome of France and GE of Britain. It put its first reactor, Unit 1, onto the power grid on August 31, 1993, and reached full load on November 27, 1993. It has now been brought into service. Fuel loading for Unit 2 was effected last November, and connection to the grid materialized last February. Its commercial operation can be expected this June.

The preliminary design of the second phase of Qinshan NPP, two 600 MW PWRs, as one of the major projects listed by the state, was approved by CNNC [China National Nuclear Corporation] in the name of the government as early as November 1992. Construction design is in full swing. Construction teams arrived at the site last March and civil construction has already been initiated. It is expected that the first concrete for Unit 1 is to be poured in 1995 and connection to the power grid is scheduled by the year 2000. Unit 2 will also hit the target one year after.

The consent has been rendered to the preliminary, feasibility study for the second phase of Daya Bay NPP, two 900 MW PWRs, a project listed also within the scope of the state programme. Meanwhile, preparatory work has begun.

The siting for Liaoning NPP (2 x 1000 MW) is finalized and the feasibility study is proceeding.

The preliminary feasibility study for Sanmen NPP in Zhejiang Province has been reviewed by the organizations and experts assigned by government, with a view to setting up a new base for nuclear power.

Currently, there is a growing demand for nuclear power in coastal provinces like Jiangsu, Fujian, Shandong, and Hainan so as to promote their economic development and alleviate their shortage of power supply. Positive actions have been taken for feasibility study and preparatory work is underway.

China's economy is in its full swing, which requires rapid development of energy and power industry. The insufficient power supply has obviously affected the economic growth in some of the provinces. A number of nuclear power plants are required in the east coastal areas as incorporated by thermal and hydropower stations. It is estimated that a nuclear power capacity exceeding 30,000 MW could somewhat handle the problem by the year 2020. At the present stage, an important task for us is, through construction of the existing NPPs, to accumulate experience, develop human resources and to master all the technology in design, fabrication, construction and operations of nuclear power plants, and to upgrade and extend nuclear fuel industry as well as heighten research and development of nuclear technology so as to meet the challenge of nuclear energy development for the next century.

2. Safety of Nuclear Power

Safety and reliability of nuclear power are attracting much attention of the international community. In this context, they are regarded as important factors in hampering the development of nuclear energy. Therefore, we strictly observe the principle that "Safety and quality are regarded as top priorities" in nuclear power construction, holding ourselves responsible to the country and the people while fully conscious of professional ethics and historical significance. And it is for this reason that all the organization structures, safety codes, and related activities are switched to putting real teeth in nuclear safety.

From this point forward in my presentation now, I'd like to avail myself of the opportunity to elaborate on the prevailing measures we've taken to ensure nuclear safety in China. First of all, there exists in China a complete system for nuclear safety. In October 1984, a government organization—National Nuclear Safety Administration (NNSA) was established independent of the then Ministry of Nuclear Industry and the now China National Nuclear Corporation (CNNC) and China Atomic Energy Authority (CAEA). It assumes responsibility for nationwide control over nuclear safety. It has the authority to issue codes and regulations on nuclear safety and directly implement safety supervision and review of nuclear power construction and on-site operation. As the executing bodies, CAEA and CNNC have

competent safety protection and emergency departments and personnel. While Qinshan NPP, Daya Bay NPP as well as many other civil nuclear facilities are supposed to enforce nuclear safety with the help of its own occupational staff members coupled with complete and stringent QA and QC system as well as other administrative rules. NNSA has the authority to act on behalf of the Chinese government whereas CAEA and CNNC embody competent operation departments to "get the job done". Thus a three-level organization structure has taken shape for the purpose of nuclear safety.

China has so far enacted and promulgated more than 100 codes, regulations, instructions, and guides of practice. In October 1986, the State Council issued "Regulation on Safety Supervision and Control for Civilian Nuclear Installations" and related guides of practice. Moreover, four codes on nuclear safety have also been published relating to design, siting, operation and quality assurance, which are reflected in the recourse to the international practice. Approval or license has to be obtained prior to siting, design, commissioning, fuel loading, operation and decommissioning of nuclear facilities; reactor operation personnel are to make access to permit. A strong safety control and on-site inspection system has been set up for all the activities to be carried out for nuclear power construction. Checkposts are set up on site and inspectors are allocated to safety control. CNNC has also issued a series of administrative rules for nuclear facilities, operation, emergency, environmental protection and radiation safety control, reflecting the full scope of procedures ranging from design, construction, operation, emergency preparedness. All of these serve to ensure a good provision for nuclear safety.

A range of activities have been carried out in the efforts to improve the nuclear safety levels. Special institutions are available in China to be engaged in theoretical and technical studies on nuclear safety. Consultation and review between Chinese and foreign experts have been repeated. Since the follow-up visit by the Pre-Operational Safety Review Team and Operational Safety Review Team of the International Atomic Energy Agency as well as other experts on emergency planning and preparedness for the past few years, overall reviews over Qinshan and Daya Bay NPPs have been conducted in respect of safety, radiation protection, environmental monitoring, and emergency preparedness. And the Chinese NPPs are recognized and accepted as safe and reliable by academic authorities on nuclear safety in the world. China is now taking an active part in drafting Nuclear Safety Convention to be issued by IAEA.

Since the government sets great store by nuclear safety and takes effective measures accordingly, nuclear safety in China becomes a fact. The past forty years have seen a good record of safety retained over China's nuclear industry. Therefore, nuclear safety in China has enjoyed a high reputation and safety culture is to be promoted among the public. Frequent communication with the public is guaranteed so that their concern over nuclear

safety will be well looked after, and their confidence in nuclear power construction will be thus built up.

3. Research and Development of Nuclear Science and Technology

Stress is also laid on research and development of nuclear science and technology, a hi-tech item falling into the category of those priorities to be financially supported by the government, so that favourable conditions are created to ensure a smooth development of Chinese nuclear energy for both the present and the future. This programme is well underway now.

Advanced PWR power plant

The research is listed as one of the state key items incorporating research on overall design, critical testing technique, and key equipment fabrication process. Test and verification for design proposal as well as outline design are to be fulfilled by 1995 as scheduled.

Fast breeder

The design of an experimental fast breeder, with thermal power up to 65MW, has been started and is going to be completed around the year 2000.

High-temperature gas-cooled reactor

A range of tests have been made. A feasibility study has been conducted in collaboration with Germany as to setting up a high-temperature gas-cooled reactor for experiments in China.

Low-temperature heat-supply reactor

With the existing 5MW nuclear heating reactor, further construction is in preparation for a 200MW thermal reactor for industry and district heating in northern China. The feasibility study has begun.

Small-sized reactor

China successfully brought forth several years back a miniature reactor with neutron source consuming enriched uranium up to 90 percent, while adopting beryllium reflector, with its power as much as 27 kW. Its wide application is found in neutron activation analysis, education, and training on reactor. Endusers come from not only domestic institutions but also foreign countries like Pakistan, Iran, Ghana, and Syria, aided financially by the IAEA.

Good operation is proceeding for the pulse reactor of China's own design and construction, undergoing a variety of experiments.

It's also worth mentioning that a sort of inherent safety small power reactor of 50MW is undergoing an experiment in response to all calls for a supplementation to energy resources in the most remote areas where few transport facilities are available.

Nuclear fusion

Tokamak facility of domestic design and construction, China Huanliu No. 1 has successfully conducted plasma conversion from low status to high status as well as high-density plasma containment, resulting in plasma density on the increase. Upgrading for the facility is expected and many new experiments are to follow afterwards. Moreover, extensive global exchange and co-operation is enhanced for that matter, while independent experiments and research work have never been slackened. China will further commit itself to the work hereof so as to bring benefit to world development in this field.

Uranium enrichment

For a couple of the previous years, tangible results have been followed in R&D on uranium isotope separation by centrifuge process at supercriticality and subcriticality as well as in experiments on laser isotope separation.

Nuclear fuel fabrication

Fuel assemblies for the power reactor in Qinshan NPP of China's own design and fabrication have been put into operation for over one year, manifesting themselves as sound in quality. Currently, joint fabrication with FRAGEM Co. of France is in its swing of the assemblies for refueling Daya Bay NPP. Smooth development has also been made on U-Si fuel elements and U-H-Zr elements. China has also provided PINSTECH Institute of Pakistan with low enriched U-Si elements for a 5MW research reactor, achieving ideal performance.

Spent fuel reprocessing

The design for a pilot plant of spent fuel from power reactors is drawing to a close for experiment with daily reprocessing capacity up to 400 Kg. Construction is bound to ensue.

Treatment and disposal of radioactive wastes

Several techniques of radioactive waste treatment, such as bituminization and cement solidification of low-level wastes and the underground hydrofracture process for disposal of intermediate level wastes have been developed and are ready for use. Studies on vitrification and final disposal of high-level wastes have been initiated.

4. International Collaboration

I'd like to draw your kind attention to the accomplishments of international collaboration with other countries. Up to now, China has signed agreements on peaceful uses of nuclear energy with a dozen of countries. Chinese nuclear experts or businessmen are sent out annually for technical exchanges, joint research work, academic conferences, and commercial activities while more and more foreign friends, experts and world celebrated companies in nuclear fields visit China to offer lectures, consulting services and to get training as well as

to undergo commercial negotiations, hence pushing ahead rapid development of international exchange and co-operation.

China has taken an active part in the IAEA's activities, and made due contributions ever since it joined the IAEA in January 1984, and was designated as a member of the Board of Governors. China has so far concluded with the IAEA the "Agreement between the People's Republic of China and the International Atomic Energy Agency for the Application of Safeguards in China" to some of its civilian nuclear facilities. China joined the "Convention on the Physical Protection of Nuclear Material", "Convention on Early Notification of a Nuclear Accident", "Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency". China is also a signatory state to the "Treaty on the Non-proliferation of Nuclear Weapons". China has made and will make unremitting efforts along with many other countries in peaceful uses of nuclear energy and guarding against proliferation of nuclear weapons.

China imports some nuclear technology and machinery from the outside world so as to raise its own technical level and to meet the domestic demand for nuclear power. China also exports some nuclear technology and materials in our good intention to promote peaceful uses of nuclear energy to benefit mankind. While the Chinese government sticks to the three principles for nuclear exports, i.e., the exported nuclear items must be ensured in writing by the recipient country government for peaceful purposes; the recipient country must place the imported nuclear facilities and materials from China under the safeguards of IAEA; and the imports hereof cannot be transferred to any third country without permission by China. On December 21, 1993, there was a ceremony for the final completion of the 10 MW heavy water research reactor constructed in Algeria by China, which is now put under the safeguards of IAEA. IAEA Director-general Dr. Hans Blix sent message of congratulation for the occasion, praising it a significant portion of the Algerian programme for peaceful uses of atomic energy. The Chashma NPP 300 MW PWR which is being constructed by China in Pakistan has also led credence to the thought of the three principles. The first concrete was poured on August 1, 1993. Nuclear co-operation with the developing countries is undertaken in the spirit of speeding up their economic development by using nuclear technology.

Asia has experienced the regional nuclear co-operation for four years, to which both the sponsor country and the related countries have made their devotion respectively. We're pleased to notice that experience and information have been exchanged pending the seminars on the four topics of research reactor, nuclear medicine, nuclear agriculture, and public acceptance, which are instrumental in mutual supplementation and common progress. And the regional co-operation will be certainly getting somewhere with the common efforts contributed from all the participating countries. China is one of them to render enthusiastic support and a case in point is that

last year a seminar on mutation breeding adopting nuclear techniques was successfully conducted in China under the auspices of CNNC. And it could be expected that more efforts will be devoted to the area.

Thank you for your attention.

Personal History—Mr. Chen Zhaobo	
11 May 1937	Born in Beijing
1961	Graduated from Leningrad University, USSR
1961-1983	Engineer, Vice Director, Chief Engineer, Senior Engineer of Beijing Research Institute of Uranium Geology
1983-1988	Executive Vice Minister of the Ministry of Nuclear Industry, Senior Engineer
1988-now	Senior Engineer, Executive Vice President of China National Nuclear Corporation

Nuclear Safety Said To Meet IAEA Standards

946B0096C Beijing KEJI BAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 11 May 94 p 1

[Article by Han Yuqi [7281 3768 3825]]

[Text] At the request of the Chinese Government, the International Atomic Energy Agency (IAEA) conducted a two-week international nuclear safety management appraisal. The appraisal team rated China quite highly and considers the work of the National Nuclear Safety Administration [NNSA] to be up to international standards.

The appraisal team, headed up by the assistant secretary of the IAEA, was composed of experts experienced in nuclear safety matters from Belgium, France, Spain, the U.S. and UK and the IAEA. This was the first time that the IAEA has come to China to evaluate the nuclear safety situation.

They visited the headquarters of the NNSA in Beijing, the Guangdong area monitoring station and the Daya Bay nuclear power plant, and they conducted their inquiry into the government organization and nuclear safety legislation, the responsibilities and duties of the nuclear safety administrative departments, their organizational structures, laws, regulations and guiding principles, licensing control measures and judgments and investigations that take place in the processing of licensing requests, as well as monitoring, law enforcement, and emergency reaction preparations.

The appraisal team believes that the NNSA has fully met its first challenge, and in from every aspect of its organizational structure, manpower, material resources; laws, regulations, and stipulations, or its safety judgments and investigation, licensing and shakedown tests, the NNSA has met the international routine standards.

One could go so far as to say that the measures adopted by NNSA in the process of its own self-development has set the model for any other new and developing nuclear nation to follow.

The Chief of NNSA, Huang Qitao, explained that the NNSA was established in October, 1984, when China had just begun the construction of a nuclear power plant. Now, 10 years later, the Qinshan nuclear power plant and Guangdong Daya Bay nuclear power plant are already built and entering full-power operations. Through the course of their construction, tests, and operations, inspections and evaluations, the NNSA has come into its own in routine safety management operations. The IAEA, having applied its international standards and its seasoned experience in the inspection of China's nuclear safety management, and given its full approval, has given a great boost to the Bureau's morale. The Chinese Government holds the NNSA in high regard. "Safety first, quality first" is the underlying principle in its nuclear development affairs, and that is a principle that will never change.

Alternative Energy

Denmark Extends Interest-Free Loan for Wind Power Project

94P60139 Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 29 Jun 94 p 1

[Text] Recently, the government of Denmark extended a 10-year interest-free loan in the amount of \$3.4 million for the construction of an electricity-generating wind power facility with a total installed capacity of 3000 kilowatts. The wind-power field is located in Nan'ao in eastern Guangdong Province. After the power station has been finished in 1995, it will generate as much as 8-10 million kilowatt-hours of electricity a year, or twice the amount now produced by the existing Nan'ao wind power project.

Yunnan Semiconductor Devices Plant: Developer of New Energy Resources

94FE0622A Chongqing XIN NENGYUAN [NEW ENERGY SOURCES] in Chinese No 4, 5 Apr 94 p 1

[Article by Fu Qizhong [0265 0366 0022] of Yunnan Semiconductor Devices Plant]

[Text] In view of pressing issues such as the energy shortage and environmental pollution, the need to develop renewable energy resources is extremely urgent. For millions of years, the sun has provided a great deal of energy as the driving force for life. This free energy is equivalent to 5.4×10^{24} joules per year, approximately ten thousand times the total energy consumption by human beings. Therefore, photovoltaics is the most promising renewable energy source.

In recent years, western nations have constructed a number of 1-10MW photovoltaic power plants and made significant progress in putting such power plants on power grids. In order to reduce the gap with the rest of the world, Yunnan Semiconductor Devices Plant imported a complete single crystal silicon solar cell production line, with an annual production capacity of 500kW, from the U.S. and Canada in 1984. After years of digestion and absorption, it has become the largest and most complete single crystal solar cell production line that produces solar cells of the highest conversion efficiency. The plant is a major advanced industry in the province. Since 1992, it has been listed among the 500 largest companies in electronics and telecommunications equipment in China. In 1993, it sold nearly 200kW of solar cells.

The solar cell industry went through a difficult development process due to lack of capital and market at the very beginning. Inspired by Minister He Guangyuan's words "Be a New Energy Developer," engineers and workers at the plant continued to innovate. Over a few years, the mean conversion efficiency has improved from 12 percent to 13.5 percent. The ND series of solar cell systems has earned the title of quality products by the Ministry of Machine Building. As quality improves and the percentage of domestically produced components rises, production cost continues to fall. This makes our products more competitive in the ever expanding market. Presently, although electricity produced by solar cells still costs more than that generated by conventional means, however, it has a bright prospect in special applications.

The solar cell market in China developed steadily. Initial breakthroughs were made in remote areas not covered by conventional power grids. In recent years, solar cells have brought electricity and lighting to microwave stations on mountaintops, firewatch towers, border patrol stations, and ranchers on the prairie. To meet various user demands, the plant offers complete services from engineering design to installation and tuning. In addition, it developed a series of accessories such as power supply controllers, dc to ac converters, and solar lamps. In order to more accurately design photovoltaic power plants, computer-aided design (CAD) is employed. Thus, the solar cell was developed from an experimental stage to become a real product. It is widely used in telecommunications, rural telephone service, television relay stations, and forest fire prevention. The size of each station is also increasing—from a few hundred Watts to several thousand Watts. As for residential power supply, the largest photovoltaic power plant is located in Gaize County in Tibet. It is rated at 20kW and the entire plant is equipped with our devices.

In western China, there are 32 counties without electricity. There are even more villages and towns without power. In addition, there are numerous remote mountain areas and isolated islands currently not covered by conventional power grids. The total demand may reach several hundred MW and the potential market is tremendous. Solar cells will be applied over an even wider area.

To better meet the demands of the users, it is vital to be able to offer high quality solar cell products inexpensively. To this end, the plant is working on a key 8th 5-Year Plan project assigned by the State Science and Technology Commission to develop a production process to produce high efficiency, low cost single crystal silicon solar cells to enable us to manufacture this key component domestically. In the past year, encouraging results have been obtained in improving conversion efficiency, raising production yield and lengthening lifetime. Furthermore, we have expanded technical cooperation with other nations, developed a variety of new solar cells and investigated novel production processes.

Yunnan Semiconductor Devices Plant is willing to work with the rest of the industry and people dedicated to the development of solar energy in China to contribute to this new energy resource.

Technical Study of High-Efficiency Monocrystalline Silicon Solar Cell

94FE0622B Chongqing XIN NENGYUAN [NEW ENERGY SOURCES] in Chinese No 4, 5 Apr 94 pp 2-3

[Article by Xu Kaifang [6079 7030 2455] of Yunnan Semiconductor Devices Plant]

[Text] Major progress in the research and development of a high-efficiency, low-cost monocrystalline silicon solar cell and its special conductor paste, a key national 8th 5-Year Plan project assigned to Yunnan Semiconductor Devices Plant, is discussed. By means of digestion, absorption and research, the mean conversion efficiency of commercial products has been raised to 13.57 percent and that of prototype specimens is as high as 14.9 percent.

Using solar cells to convert solar energy to electricity has numerous advantages such as safety, reliability, no noise, no pollution, no fuel consumption, no need for high-voltage lines, short construction time, flexible plant size and, unmanned operation. It will be one of the most important sources for electric power in the future. Therefore, a number of nations have invested huge sums of money in its research and development and very rapid progress has been made. By the end of 1992, the total capacity of photovoltaic power plants had reached 386.6MW.

Yunnan Semiconductor Devices Plant, the Solar Energy Institute of Yunnan Normal University, Kunming Precious Metals Institute and Kaifeng Solar Cell Plant of Henan have been engaged in a key 8th 5-Year Plan project entitled "Research and Development of Domestic Production of High-Efficiency, Low-Cost Monocrystalline Silicon Solar Cell and Its Special Conductor Paste" since 1991. This project is also listed as a key technical project and a torch program by the Science Commission of Yunnan. On the basis of the overall objectives and specific requirements, after over two years of hard work, our product is ahead of other domestic manufacturers and is equivalent to the level of

similar products in the late 1980's. The following is a brief discussion of our major progress.

- (1) Digesting, absorbing and improving imported technology. In 1984, the Yunnan Semiconductor Devices Plant imported a complete production line for monocrystalline silicon solar cell that represents the state of the art of the early 1980s from the U.S. and Canada. After 3 years of installation, debugging, and production, as well as through digestion and absorption, it gradually stabilized. Conversion efficiency of the product being manufactured is meeting the 12-percent level as specified in the contract. It passed appraisal by the province at the end of 1989.

Between 1990 and 1991, we continued to digest this imported technology. Not only did we analyze its theory and mechanism but also conducted experimental confirmation. Key areas were repeatedly verified. Procedures that are advanced and rational are included in the production process. Procedures that are unrealistic and impractical for production are being perfected and improved. The key areas are focused on the equipment and processes used to grow monocrystalline silicon and to cut silicon wafers and control parameters and process specifications associated with the fabrication of matte surface and p-n diffusion junction. As a result, both performance and yield are drastically improved. The mean conversion efficiency reached 12.6 percent.

- (2) Significant progress was made in 1992 in the key Eighth 5-Year Plan project and in adapting compatible processes to produce high efficiency solar cells.

The key step in solar cell production is to form a diffusive p-n junction. After repeated experimentation, we changed the process from a single-step diffusion to a two-step diffusion process to effectively improve the distribution of impurities in the emitter region and the characteristics of the p-n junction.

The paste formula and back field process were improved. A p-p⁺ junction is formed in the base to introduce an internal electric field to lengthen the diffusion length of minority carrier by approximately 30 μm . This extends the spectral response of the solar cell by approximately 400 Angstroms toward longer wavelength and enhances its absorption in the red.

The process to form a matte surface was further improved to a two-step process so that the size, uniformity and density of the tetrahedrons are optimal. More than 90 percent of the incident light is absorbed. Table 1 shows a comparison of test results obtained from TDB₁₀₀ specimens produced by Yunnan Semiconductor Devices Plant on 28 December 1992 to those of comparable products manufactured by Sharp.

Table 1. Comparison of Electrical Parameters of Yunnan Semiconductor Devices Plant's TDB₁₀₀ Solar Cell to Those of Sharp's NT₁₀₂ Solar Cell (made in the mid-to late 1980s)

Electrical Parameter	TDB ₁₀₀	NT ₁₀₂
I _{sc} (mA)	2442	2450
I _{max} (mA)	2184	2270
V _{oc} (mV)	604	600
V _{max} (mV)	504	485
P _{max} (mW)	1101	1100
FF (%)	74.5	74.9
η (%)	14.1	14.1
η (commercial product, %)	13	

- (3) In 1993, the key areas of research were as follows:

Anti-reflective (AR) Coating

To further improve solar cell conversion efficiency, it is necessary to minimize loss due to reflection. To this end, a high quality AR coating needs to be deposited on the matte surface. However, AR coating is a complicated technology. Ideally, it should be approximately 700 Angstroms thick and uniform. The coating must stick to silicon and the sealant used and has the same thermal expansion characteristics. Its physicochemical properties must be stable. In particular, it must have compatible optical characteristics.

The optical thickness of the AR coating, n_d , incident wavelength, λ , index of refraction of the sealant, n_1 , and index of refraction of silicon, n_2 , should satisfy the following equations.

$$n_d = \lambda/4, n = (n_1 n_2)^{1/2}$$

After repeated experimentation of the performance characteristics and preparation processes of SiO₂, SiO₂, TiO₂, MgF₂ and SnO₂, the AR coating was optimized. The short circuit current of AR coating covered solar cells is raised by 50-100mA and the open circuit voltage is increased by more than 10MV.

Grid Line

The shape, size and density of grid line play a critical role on the performance of a solar cell. In order to increase the light receiving surface, grid lines should be fine and few. However, if it is too thin and sparse, the collection of light-induced carriers will be adversely affected and serial resistance will rise. Hence, we proceeded to conduct a study on solar cell grid lines with some success. It is still in progress.

"Buried Layer" Technology

Investigation was done on diffusion source and diffusion process on the basis of a two-step diffusion process. A "buried layer" technique is used to rigorously control doping concentration in the emitter and junction depth.

The distribution of doping distribution is optimized to form a $n^+ - n$ junction in the emitter to further enhance the establishment of an internal electric field to reduce serial resistance. This avoid the formation of a "dead layer" due to excessive impurity level which adversely affects minority carrier lifetime. It enhances the separation carriers produce by light by the p-n junction.

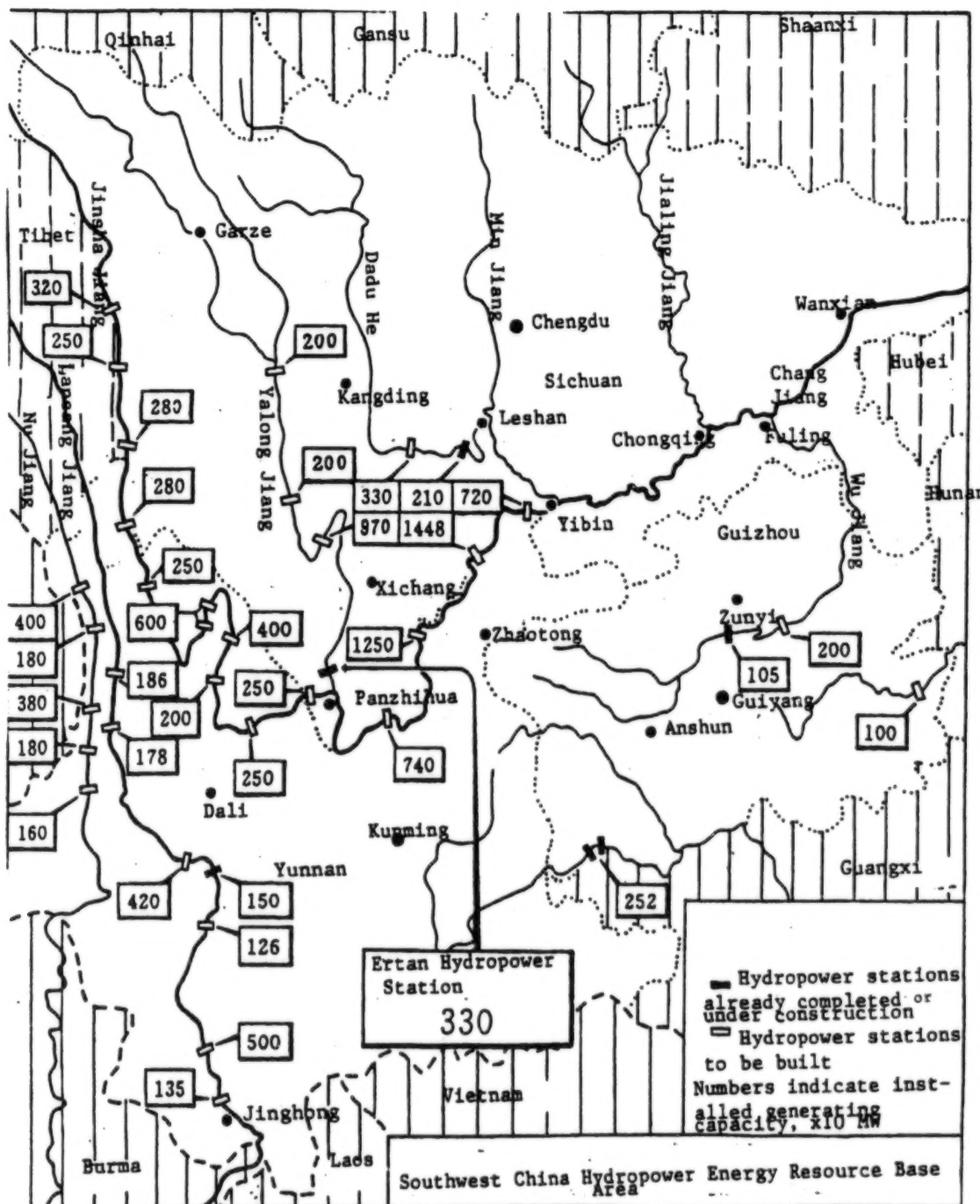
In 1993, the mean conversion efficiency of solar cells produced at the plant has reached 13.57 percent. The conversion efficiency of the 17.54 percent solar cell is over 14 percent. Table 2 shows the test results of specimens of our TDB₁₀₀ solar cell produced on December 10, 1993.

**Table 2. Test Results of TDB₁₀₀ Specimens on
10 December 1993**

I_{sc} (mA)	2530
I_{max} (mA)	2313
V_{oc} (mV)	610
V_{max} (mV)	504
P_{max} (mW)	1166
FF (%)	75.5
η (%)	14.9

Erratum—Ertan: Centerpiece of Southwest Hydropower Development Plan

[Text] The following map was inadvertently omitted from the JPRS Science and Technology China report CST 94-008 which was published on 24 May 1994. It is a map of the Southwest China Hydropower Energy Resource Base Area and should be part of article 94B60021 entitled Ertan: Centerpiece of Southwest Hydropower Development Plan, which begins on page 25 of CST 94-008.



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